ANTECEDENTS AND OUTCOMES OF END USER COMPUTING COMPETENCE

THESIS

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David A. Case

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Abstract

The tremendous proliferation of end user computing (EUC) in the workplace over the past few decades is cause for concern in public and private organizations. Computer use has moved from individuals working with "dumb" terminals in centralized networks to individuals operating personal computers, just as powerful as yesterday's mainframe. The end user has had to evolve and will continue evolving as well; from someone with low level technical skills to someone with a high level of technical knowledge and information managerial skills. Because EUC continues growing more sophisticated, end users must not only maintain a level of competence, but prepare for the next generation of computing technology. Doing so will enable organizations to continue enjoying the positive benefits of EUC success. Research indicates that EUC success may depend on end user competence. Using Structural Equation Modeling (SEM) to test an integrated model of EUC success, the results of this study show that computer training, education level, beliefs about computer systems and the ability to operate them lead to end user computing competence. Additionally, results show that computer system use, a factor in achieving EUC success, is an outcome of end user computing competence. The overall conclusions drawn from this study is that the Air Force organization may be able to improve its efforts to successfully use computing technology, however it appears individual personnel have the competence to do so already. There may be additional underlying factors contributing to the lack of significant computing success, the discovery of which is a prospect for future research.

ANTECEDENTS AND OUTCOMES OF END USER COMPUTING COMPETENCE

I. Introduction

Overview

For years, academics and practitioners have studied end user computing (EUC) (Doll and Torkzadeh, 1988; Yaverbaum, 1988, Igbaria, 1990; Igbaria and Nachman, 1990; Igbaria and Zviran, 1991; Igbaria and Toraskar, 1994; Etezadi-Amoli and Farhoomand, 1996; Rivard and Huff, 1988; Amoroso and Cheney, 1991; Suh, Kim, and Lee, 1994; Igbaria, Guimares, and Davis, 1995). EUC are those activities end users engage in to produce and utilize information for decision-making purposes (Cotterman and Kumar, 1989). Two factors combined to form the EUC environment we know today. First, with the advent of fourth generation programming languages (4GL) and personal computers (PC), non-programming end users of computers were able to by-pass professional programmers and organizational IS departments to obtain desired results from computer information systems (Nelson, 1991). Second, the growing availability of personal computers as evidenced by a 100% increase in PC shipments during the mid-1980s, growing to 48 million PC shipments by 1995 allowed the widespread use of user-friendly applications such as spreadsheets and word processing (Harris, 2000).

Previous research shows the tremendous revolution EUC has undergone over the past few decades. It has moved from individuals working with "dumb" terminals in centralized networks to individuals working with personal computers, just as powerful as yesterday's mainframe, in a distributed client/server environment. The end user has had to evolve as well; from someone with low level technical skills to someone with a high

level of technical knowledge and information managerial skills (Harris, 2000; Applegate, 1998). Because EUC is growing more sophisticated, end users must maintain a level of competence with EUC in order for organizations to remain competitive (Cragg and Zinatelli, 1995; Mirani and King, 1994). Research indicates that EUC success may depend on end user competence (Shayo, Guthrie, and Igbaria, 1999; Sohal and Lionel, 1998).

End user competence is a combination of individual computing skills and knowledge along with the ability to apply the skills and knowledge to complete computer and information related tasks for organizational decision-making (Munro, Huff, Marcolin, and Compeau, 1997; Huff, Munro, and Martin, 1988). EUC success is based on those activities end users engage in to produce and utilize information for decision-making purposes, and accomplish those activities efficiently and satisfactorily. Because of the proliferation of organizational dependency on EUC, a high level of EUC success is tantamount to organizational success (DeLone and McLean, 2002) resulting in benefits such as productivity, core competency advancement, and a competitive advantage over industry adversaries (Cotterman and Kumar, 1989; Javidan, 1998; Widmann, Anderson, Hudak, and Hudak, 2000; Blili, Raymond, and Rivard, 1998; Zhang and Lado, 2001).

This study has three purposes. First, it is an investigation into those factors that are considered antecedents of user competence in the Air Force (AF) organization. Understanding these factors may allow the AF to establish programs to increase end users' skill, knowledge, and the ability to apply each in the EUC environment. Second, it looks at EUC success as an outcome of user competence. EUC success leads to better decision-making and may enable AF leadership to justify investments in workforce

development and EUC technology. Finally, it will examine those factors that combine to determine EUC success in an attempt to see if the AF is positioned for EUC success.

Background

Recently, organizations began to realize that quality information for decision-making can only come from creating an environment that takes advantage of computer systems' capabilities and the skills of the workforce using them (Munro, Huff, Marcolin, and Compeau, 1997; Cutis, Hefley, Miller, and Konrad, 1997; Roche, 2003). Information used in decision-making is the product of computer systems and history has shown repeatedly that superior information is fundamental to successful combat, combat support, and business operations (Office of AF-CIO, 2002).

The Office of the AF Chief Information Officer (2002) established the AF Information Strategy in which two primary goals are: "Ensure the Air Force takes advantage of state-of-the-art information technology…" and "Empower a focused, well-trained and motivated workforce prepared to continually search out and embrace new information-based capabilities for the Air Force." Combining computer technology investments with appropriate investments in developing computer-related skills and knowledge in AF personnel may maximize computing capability and produce quality information for decision-making purposes. To emphasize the importance of maintaining competence with technology in the workforce, the Secretary of the Air Force, James G. Roche, outlined the AF's new core competencies in which he indicated that the capabilities of the USAF rely not only on smart technology investments, but also on the abilities of our personnel to practice "critical analysis" and "intellectual flexibility" when

using technology (Roche, 2003). The intention is to ensure personnel have the skills and knowledge to, not only use the technology, but practice creative and innovative application of those skills and knowledge to enhance the capabilities of technology.

Training is one factor previously identified in literature as having a link with users' skills and abilities (Nelson and Cheney, 1989). Previous research conducted at the Air Force Institute of Technology (AFIT) found end users unhappy with the quality and amount of computer training they received and their ability to use computers (Bass, 1990; Coleman, 1989; Van Huffle, 1996). Participants in one study showed a high level of concern about their ability to complete job tasks using computers. This study showed that over 30% of AF enlisted administrators believed the level of computer training received was insufficient and almost 25% believed their own level of computing competence inhibited their ability to use computers to complete job tasks (Bass, 1990). More recently, at the request of the AF, the Gartner Group (2002) conducted a total cost of ownership (TCO) study. In that study, 31% of AF participants felt computer related training was poor or needed improvement.

The AF spends an average of $10,000 to maintain each desktop computer system. This figure is on par with industry averages. Of the $10,000, $24 is dedicated to training computer end users (Gartner Group, 2002), lower than the $131 industry average. The Gartner Group (2002) attributes the low IT-to-user personnel ratio to the low investment in training end users. The AF employs one IT support person for every twenty-three end users whereas the industry average is one IT support person for every thirty-one end users. The presence of a low IT-to-user personal ratio increases the cost of computer operations and is an indication that most end user employees are using computers;

however, they are not using them well (Brynjolfsson and Hitt, 1998; Gartner Group, 2002).

Problem Statement

Based on new AF core competencies (Roche, 2003), the USAF has made a commitment to improving the skills and knowledge (e.g. competence) of its workforce. The AF is a leader in the use and acquisition of new technology. One problem facing the AF is matching current technology with end users capable of exploiting its capabilities. Increasing the computing competence of the workforce will prepare end users to successfully exploit the capabilities of current technology today and prepare to successfully exploit the capabilities of newly acquired technology tomorrow. An understanding of those factors which lead to end user computing competence will enable the AF to focus resources to improve overall workforce competence.

A second problem facing the AF and other federal agencies is spending in information technology. In 2001, the AF's IT budget topped 3 billion dollars. Organizations within the AF call for bigger, better, faster IT to run operations, yet have little understanding of the current IT capabilities. Increasing end user computing competence to fully exploit the capabilities of current technology may avert unnecessary calls for new computer systems. Thus, an increase in spending on those areas, which increase end user computing competence, may reduce the overall cost of IT.

Finally, understanding the degree to which end users are skillful and knowledgeable with current technology combined with the ability to creatively apply

those skills and knowledge may assist in establishing training needs when it is necessary to acquire new IT systems.

Research Questions

Following the EUC behavioral and psychological school of thought (Harris, 2000), this research will develop a model of antecedents to user competence and evaluate the outcomes of user competence. The model will integrate theoretical concepts from three previously validated models: the Information System Success Model (ISSM) (DeLone and McLean, 1992, 2002; Goodhue and Thompson, 1995; Etezadi-Amoli and Farhoomand, 1996; Igbaria and Tan, 1997; Guimaraes and Igbaria, 1997; Gelderman, 1998; Torkzadeh and Doll, 1999; Seddon, 1997; Pitt, Watson, and Kavan; 1995), the Social Cognitive Theory (SCT) (Bandura, 1986; Compeau and Higgins, 1995a, 1995b; Compeau, Higgins, and Huff, 1999), and the Technology Acceptance Model (TAM) (Davis, 1989, 1993; Davis, Bagozzi, and Warshaw, 1989; Mathieson, Peacock, and Chin, 2001; Hartwick and Barki, 1994; Venkatesh and Davis, 2000; Igbaria, 1993; Igbaria et. al., 1995; Hubona and Kennick, 1996; Al-Gahtani, 1998).

The specific goal of this research is to identify and measure external variables and user beliefs that lead to user competence and discover whether or not factors of EUC success are outcomes of user competence. A relatively new concept in EUC research, the user competence construct is introduced as conceptualized and operationalized by Murno et. al. (1997). In an effort to narrow the scope of the study, external variables will include only those factors identified in previous research as individual or user

characteristics. The results of this study will attempt to answer the following research questions:

1. Are User Characteristics and Beliefs antecedents to User Competence?
2. Are EUC success factors outcomes of User Competence?
3. Is the AF positioned for current and future EUC success?

Summary

This chapter discussed EUC's evolution and the net benefits it can have on an organization. Successful EUC was presented as a possible outcome of user competence and user characteristics and beliefs were presented as possible antecedents of user competence. A background of the problems the AF faces as it struggles to understand EUC was presented. The problem of ensuring end users have the computing competence needed to ensure computing success in the organization is introduced. Finally, to address this problem, the three research questions this study will investigate were presented.

The next chapter will review the literature on user competence and its proposed relationship to the ISSM, TAM, and SCT. Specific hypotheses concerning these relationships will be proposed. Chapter III will outline the methodology for conducting the research, to include population characteristics and data collection technique. Chapter IV will provide an analysis of the data collected, and chapter five will present a discussion of the findings, limitations of the study, implications and suggestions for future researchers and AF practitioners.

II. Literature Review

Introduction

It is widely understood that end user computing (EUC) technology offers great potential for improving an individual's job performance. However, performance gains are often obstructed by the individuals' ineffective use of available systems (Mawhinney and Lederer, 1990). A primary objective in EUC research is to assess the benefits EUC technology brings to an organization and understand the determinants of those benefits. Understanding factors that influence EUC success is an important issue that continues to interest researchers. In the course of this research effort, a conceptual model of EUC is proposed with individual characteristics and beliefs acting as antecedents to user competence and EUC success as an outcome of user competence.

This literature review is organized as follows: First, EUC success and User Competence are identified and defined. An overview of EUC is presented, followed by a discussion of individual computing competence as it relates to organizational and individual competence. Then, theoretical models commonly used in EUC and IS research are presented as a framework on which to base a conceptual model of EUC. The User Competence construct, as conceptualized by Munro, et. al. (1997), is introduced into the conceptual model as an outcome of User Characteristics and Beliefs leading to System Use and User Satisfaction, factors used to evaluate EUC success. Finally, the overall research model with the associated hypotheses is presented.

End User Computing

As the unit of analysis for this study, it is important to specifically define the "end user." End users are those individuals who interact directly with an organization's computer hardware and software at the application level to produce and utilize information that is accessible by the computer systems and used in the organization's decision-making process (Harrison and Rainer, 1992). End users are not the organization's IT/IS professionals who develop and control computer hardware and software systems (Cotterman and Kumar, 1989; Yaverbaum, 1988; Guimaraes and Igbaria, 1997).

End user computing (EUC) are those activities end users engage in to produce and utilize information. Examples of these activities are: searching, accessing, storing, maintaining, and formatting information for use by the organization's decision-making process (Cotterman and Kumar, 1989). EUC also includes efforts by users to develop their own applications for personal and, in some cases, organizational use. EUC success is most often identified by two prominent measures of IS success found in literature: user satisfaction and system use. A number of studies have focused on user satisfaction (Doll and Torkzadeh, 1988; Etezadi-Amoli and Faroomand, 1996; Gelderman, 2002; Igbaria and Nachman, 1990; Rivard and Huff, 1988), system use (Goodhue and Thompson, 1995; Davis, 1993; DeLone, 1988; Igbaria, 1990; Igbaria and Toraskar, 1994;) or both (Amoroso and Cheney, 1991; Al-Gahtani and King, 1999; Barki and Huff, 1990; Blili, Raymond, and Rivard, 1996; Compeau, Higgins, and Huff, 1999; Guimaraes and Igbaria, 1997; Gelderman, 2002) measures of EUC success. For the purpose of this study, examining measures of both User Satisfaction and System Use will identify EUC

success. For a computer system to be successful, users need to accept and use the system (Davis, 1989). While system use is one measure, it cannot be used alone as a measure of EUC success in mandatory use environments. Based on the premise that a satisfied end user will use the system more productively than an unsatisfied end user, the attitudinal measure, user satisfaction, is included as a factor of EUC success (Yaverbaum, 1988). Therefore, high system use and high user satisfaction are considered indications of EUC success.

Past management information systems studies show two relevant research threads, one follows the study of individual IS and the other studies overall EUC. In today's business and social environment, emphasis is on integration of IT services. With the advent of distributed computing, numerous IS and software applications are accessed through a single computer terminal tied to a network. Several studies have determined the differences between the characteristics of individual IS and overall EUC are relatively small (Ein-Dor and Eli Segev, 1991; McLean and Kappelman, 1992; Etezadi-Amoli and Farhoomand, 1996). Ein-Dor and Eli Segev (1991) found that the EUC concept is better understood in the general context of IS theory and findings in both disciplines are generally consistent with each other. In addition, McLean and Kappelman (1992) found that EUC is no longer associated with specific hardware or software, and the scope of EUC is steadily drawing closer to that of IS. This study will follow the example of Etezadi-Amoli and Farhoomand (1996), by adopting the domain of the IS success model (Delone and McLean, 1992, 2002) and applying it to EUC success. Rather than focus on one specific application or system, entire knowledge domains that make up EUC are evaluated to determine overall EUC success.

Competence

Organizational and Individual

Organizational competence can be defined as the skills and resources firms possess and the way in which each is used to maintain the organization's standing within industry (Javidan, 1998). An organization's core competence is a unique collection of skills, knowledge, and resources integrated and shared across functional units of an organization in order to maintain a competitive advantage over industry adversaries. At the individual level, competence is a collection of skills and knowledge gathered from education, training, and experience (Mirabile, 1997). In order for an organization to grow in capabilities and competencies, individuals must increase their level of competence (Widmann, Anderson, Hudak, and Hudak, 2000). Greater individual competence ensures personnel and the organization are more productive and effective. (Blili, Raymond, and Rivard, 1998). The link between organizational and an individual competence is identified through the final product, a competitive advantage (Prahalad and Hamel, 1990). Through competent individual use of computers, quality information is produced in order to maintain and further the organization's core competencies.

The AF has built a computer communications network that provides the capability to achieve information superiority. Unfortunately, a high tech and quality computer network alone does not guarantee information superiority. Computer networks are physical resources; skilled and knowledgeable personnel are needed to operate these computer systems. Secretary of the Air Force James G. Roche (2003) emphasizes the importance of developing skills and knowledge in the workforce when he outlined the concept of Developing Airmen as one of the AF's newest Core Competencies.

> …we are dedicated to ensuring they receive the education, training, and professional development necessary to provide a quality edge second to none. The full spectrum capabilities of our service stem from the collective abilities of our personnel; and the abilities of our people stem from a career-long focus on the development of professional airmen (Roche, 2003).

Leveraging the skills and knowledge developed in individuals and shared across functional and organizational boundaries is what will give the AF an advantage over its adversaries. As Zhang and Lado (2001) point out, it is possible for organizations to link computer use with enhancing organizational competence to gain competitive advantages.

End User

There are a considerable number of studies focusing on individual end users' skill and knowledge. The skill and knowledge of end users are referred to in literature by a wide variety of names: computer literacy (Bell, 1990; Coleman, 1989; Winter, Chudoba, and Gutek, 1997), computer proficiency (Nelson, 1991), computer skills (Laboris, 1998), computer abilities (Lee, Kim, and Lee, 1995; Nelson, Kattan, and Cheney, 1991, Rockart and Flannary, 1983), user sophistication (McQueen and Mills, 1998; Huff, Marcolin, Munro, and Compeau, 1995), and user competence (Munro, Huff, Marcolin, and Compeau, 1997; Blili, Raymond, and Rivard, 1998, Marcolin, Compeau, Huff, and Munro, 2000). An examination of popular IT models attempting to explain successful computer use (Technology Acceptance Model (TAM) (Davis, 1989; 1993), Information System Success Model (ISSM) (DeLone and McLean, 1992, 2002) and Task-Technology Fit model (TTF) (Goodhue and Thompson, 1995)) reveals that the culmination of users' skills, knowledge and ability to apply the acquired skill and knowledge is not considered. In addition, few empirical studies could be found that specifically focused on the impact an end user's skill and knowledge has on EUC success (DeLone and McLean, 1992).

In this study, end user skill and knowledge will be evaluated by the User Competence construct as proposed by Marcolin et. al. (2000) and Munro et. al. (1997). User Competence is defined as "the user's potential to apply technology to its fullest possible extent so as to maximize performance of specific job tasks" (Marcolin et. al., 2000). This broad definition of User Competence takes into account the culmination of an individual's computer knowledge and skills rather than focusing on one specific software application or information system. A further breakdown of the User Competence construct shows that it consists of three independent dimensions: breadth, depth, and finesse (Figure 1) (Munro et al,. 1997). Within each of these dimensions are three computer knowledge domains: software, hardware, and computer concepts & policies.

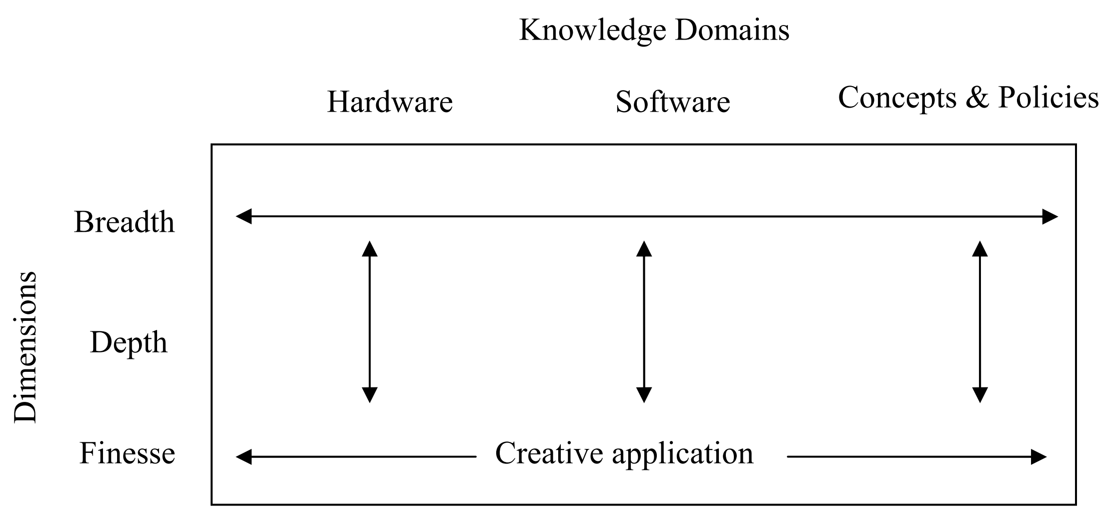

Figure 1: Conceptualization of User Competence (Munro et. al., 1977)

The first independent dimension of User Competence is *breadth,* the variety of skills and knowledge an individual possesses about computer knowledge domains and can apply to job tasks. Secondly, *depth* refers to the completeness of the user's current

knowledge and skills in the realm of each computer knowledge domain. Finally, finesse is defined as the ability to creatively and fluently apply both breadth and depth to find new and innovative uses for technology (Munro et al., 1997).

The importance of user competence as conceptualized by Munro et. al. (1997) lies in its potential to enable computer users to maximize the use of current technology to and prepare them to quickly adapt and maximize the use of future IT acquisitions.

Theoretical Framework

To build the research framework, a review of behavioral studies relating to users adoption of information technology was conducted. Several theoretical perspectives influence the present study. These perspectives offer evidence to explain variance in EUC success and contain factors that may also explain variance in User Competence.

Information Systems Success Model (ISSM)

Information systems and EUC success are multidimensional constructs requiring multiple measures to evaluate (DeLone and McLean, 1992, 2002; Etezadi-Amoli and Farmoomand, 1996). DeLone and McLean (1992) consolidated over 180 published articles to categorize these measures into six interdependent dimensions of information systems success. Their work consolidated the wide-ranging dependent variables researchers had previously used as dependent variables for IS success. Their purpose was to organize the varied research into a comprehensive model of IS success to establish a basis for future IS research.

DeLone and McLean's IS Success model (1992) stems from Shannon and Weaver's (1949) (see Figure 2) mathematical approach to the theory of communication

where an IS system acts as the information source, sending the message through the system to the receiver. The technical level addresses the accuracy and efficiency of the system, the semantic level represents the success in conveying the message, and the effectiveness level is the effect the message has on the receiver.

Shannon And Weaver (1949)	Technical Level	Semantic Level	Effectiveness Level			
Mason (1978)	Production	Product	Receipt	Influence On Recipient		Influence On System
DeLone And McLean (1992)	System Quality	Information Quality	System Use	User Satisfaction	Individual Impact	Organizational Impact

Figure 2: Categories of Information System Success (DeLone and McLean, 1992)

Mason (1978) adopted the theory of communication to the measurement of information systems. Using a product oriented approach for IS measurement, he used the terms production and product to describe the technical and semantic levels of communication. He re-labeled effectiveness as influence to demonstrate the impact information products have on all stakeholders, such as the individual, workgroup, and/or organization. Mason (1978) also described the events surrounding the receipt of a message or information as hierarchical.

DeLone and McLean (1992) used these previous studies as a guide to develop their taxonomy of system success (see Figure 3). System Quality falls in line with Shannon and Wearver's (1949) technical level and Mason's (1978) production level. This might be considered the hardware portion of the overall information system, responsible

for producing and sending the information. Information Quality falls in line with Shannon and Weaver's (1949) semantic level and Mason's (1978) product level. This might be considered the message the information system is sending to the recipient. System Use, User Satisfaction, Individual Impacts and Organizational Impacts align with Shannon and Weaver's (1949) and Mason's (1978) effectiveness and influential levels respectively. At this level, the influence on information system users and other recipients of the information are analyzed by measuring System Use and User Satisfaction. Individual Impact and Organizational Impact are measures the impact an information system has on management and organizational performance (DeLone and McLean, 1992).

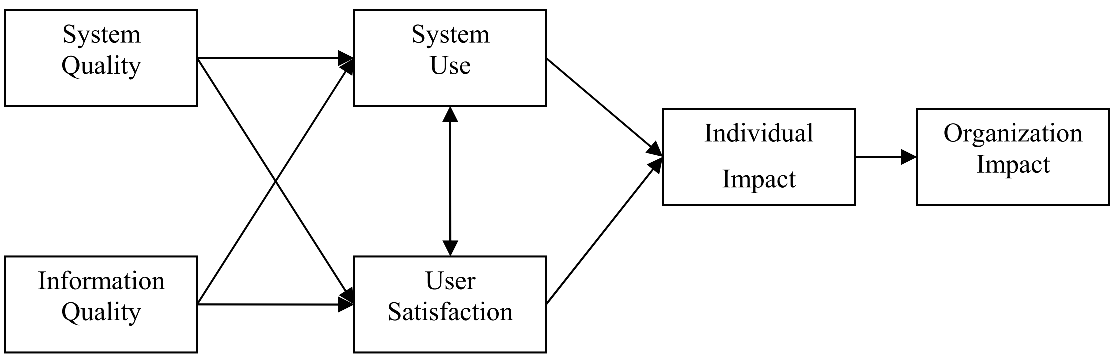

Figure 3: DeLone and MeLean's Information Success Model (1992)

The ISSM (DeLone and McLean, 1992) makes several contributions to the study of information systems and information technology in general. First, it consolidates previous research relevant to the topic. Second, it groups together measures of information system success. Third, it differentiates success for various stakeholders in an information system. Finally, it is widely accepted as a basis for further empirical and theoretical research (Ballantine, Bonner, Levy, Martin, Munro, and Powell, 1998).

DeLone and McLean (1992) maintained their model is causal in nature and acknowledge the model they present is not complete, “This success model clearly needs further development and validation before it could serve as a basis for the selection of appropriate information system success measures" (DeLone and McLean, 1992:p. 88). A number of researchers took on the challenge of developing and validating parts of their model (Goodhue and Thompson, 1995; Etezadi-Amoli and Farhoomand, 1996; Igbaria and Tan, 1997; Guimaraes and Igbaria, 1997; Gelderman, 1998; Torkzadeh and Doll, 1999). These researchers empirically tested parts of the model and confirmed that the relationships proposed between dimensions of success were significant and causal in nature. These findings identify the original ISSM as a well-established framework for reporting and comparing IS research (DeLone and McLean, 2002).

Ten years after the original ISSM was established, DeLone and McLean (2002) revisited the ISSM to examine the researchers' findings. They found more than 150 articles, books and conference proceedings that referenced the original ISSM. Based on what other researches discovered, DeLone and McLean (2002) presented a reformulated version of their earlier model (see Figure 4). A summary of the major revisions follows:

1. Addition of Support Quality as a construct (Pitt, Watson, and Kavan, 1995).
2. Consolidates the impacts IS have on stakeholders into a single Net Benefits construct (Seddon, 1997).
3. Changes the System Use construct from actual system use to Intent to Use (Seddon, 1997).
4. Includes feedback loops to represent the cyclical nature of communication (DeLone and McLean, 2002).

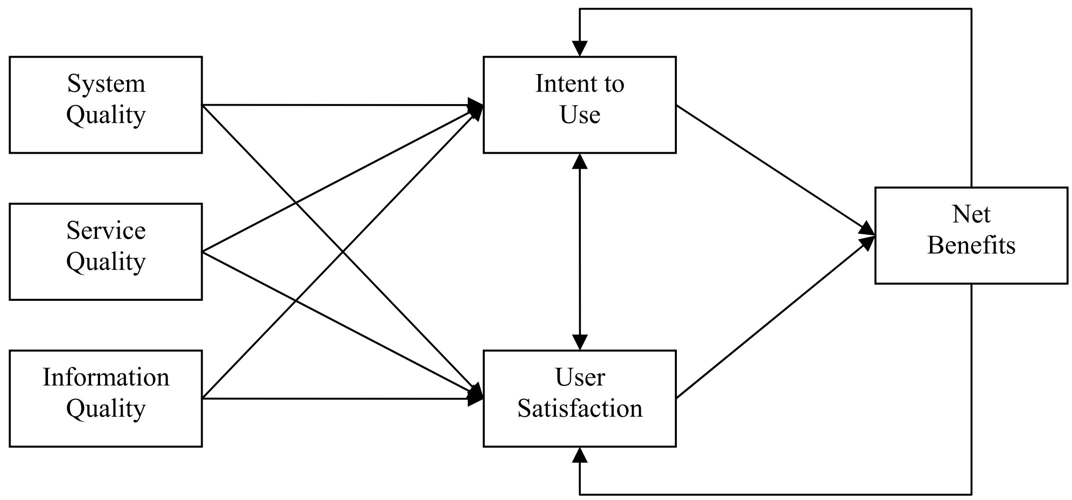

Figure 4: Reformulated ISSM (DeLone and McLean, 2002)

Shannon (1949) defined an information source as that which produces a message to be communicated and destination as the person (or thing) for whom the message is intended. This view presents the system as both the message source and path to the recipient. This assumes the message originates internal to the system, not the person operating the IS. This limitation is apparent in DeLone and Mclean's (2002) revised model as well. While it improves upon previous research by recognizing the cyclical nature of communication and the benefits communication of information brings to shareholders, it neglects the important aspect of human interaction with a computer system. It fails to recognize the user's "quality" or competence with manipulating the system to obtain information necessary for a positive benefit.

Social Cognitive Theory (SCT)

The SCT (Bandura, 1977, 1986) is a widely accepted model of individual learning behavior. The foundation of SCT is the model of triadic reciprocality (Figure 5).

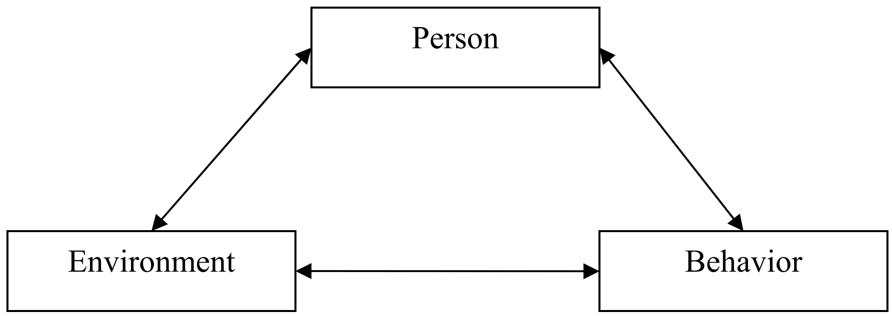

Figure 5: Triadic Reciprocality (Bandura, 1986)

Bandura (1986:18) suggests that the person, the behavior, and the environment are all entwined to create learning in an individual, "In the social cognitive view people are neither driven by inner forces nor automatically shaped and controlled by external stimuli. Rather, human functioning is explained in terms of a model of triadic reciprocality in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other." In short, Bandura's model is based on the view that (a) personal factors in the form of cognition and affect, (b) behavior, and (c) environmental influences create interactions that result in a triadic reciprocality (Compeau and Higgins, 1995a).

There are two sets of expectations guiding behavior. First, expectations are related to outcomes of behavior. Individuals are more likely to participate in behaviors which result in favorable outcomes (Compeau and Higgins, 1995a, 1995b). Second, expectations are related to self-efficacy. Self-efficacy is the belief an individual has about his/her ability to perform a particular behavior. Higher self-efficacy relates a positive attitude toward one's ability to perform a particular behavior. Individuals are more likely to participate in behaviors in which he or she believes in his/her ability to

perform a specific behavior that will result in successful outcomes (Compeau and Higgins, 1995a, 1995b).

Compeau and Higgins (1995a; 1995b) conducted a series of studies in an attempt to relate computer self-efficacy to computing environments. They found that self-efficacy is an important determining factor when evaluating system use and performance. They also recognized an important limitation of the Social Cognitive Theory. Beliefs about outcomes are not sufficient to influence behavior if individuals doubt their own ability. To understand the effect beliefs have on behavior, additional beliefs about the computer system should be evaluated.

Technology Acceptance Model (TAM)

The TAM (Davis, 1989, 1993; Davis et. al., 1989), based on the Theory of Reasoned Action (TRA)(Ajzen and Fishbein, 1980), is a widely studied model that is concerned with the determinants of intended behaviors. According to TRA, an individual's performance of a specific behavior is determined by his or her behavioral intention to perform the behavior (Ajzen, 1991). TAM (see Figure 6) predicts a person's acceptance of IT by specifying causal relationships among belief and attitudinal constructs that mediate the influence of external variables on usage behavior. TAM asserts, through its theoretical foundations in the TRA, the principal influence of beliefs on attitudes (Ajzen and Fishbein, 1980) will eventually impact actual technology use.

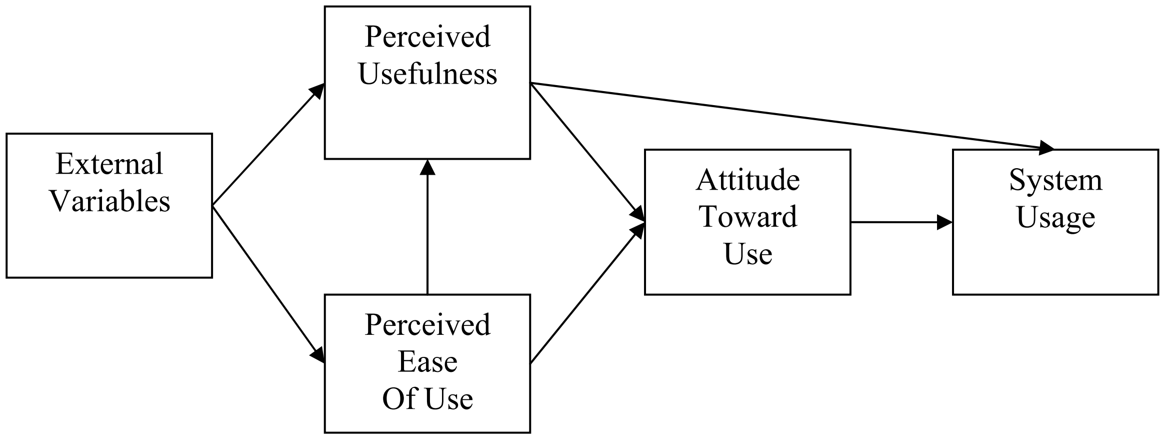

Figure 6: Technology Acceptance Model (Davis, 1991)

If the individual does not perceive the system as useful and easy to use or has a poor attitude toward using the system, TAM suggests there is a chance the system will not be used (Davis, 1989). The assumption TAM makes is that system use is under the user's volitional control (Davis, 1989). Mathieson, Peacock, and Chin (2001) point out that voluntary use assumes there are no other barriers to system use. There are times when an individual lacks resources such as time, money, or competence to use a computer system. In addition, TAM does not take into account subjective norm, the perceived social pressure to use a computer system (Hartwick and Barki, 1994). Venkatesh and Davis (2000) found a direct effect on the intention to use a system when the usage context was perceived as mandatory based on subjective norm. In these cases, TAM may overstate or miss important sources of variance (Mathieson et. al., 2001; Hartwick and Barki, 1994; Venkatech and Davis, 2000).

Conceptual Model

In this section, the three models previously described (ISSM, SCT, TAM) will be integrated to form a conceptual model of EUC success. User Competence is introduced as an antecedent to EUC success factors, System Use and User Satisfaction. The purpose of consolidating the models and including User Competence is to negate the observed limitations in the previously described models. The limitations are summarized below:

1. ISSM - System inputs do not take into account "user quality" or competence (DeLone and McLean, 1992).
2. SCT - Beliefs about abilities or outcomes are not enough to explain behavior (Compeau, Higgins, and Huff, 1999).
3. TAM - Doesn't account for involuntary or perceived involuntary system use (Mathieson, Peacock, and Chin, 2001).

Figure 7 shows an integrated conceptual model of the SCT, TAM, and ISSM. User Characteristics are the external environmental variables originating from SCT and TAM. User Beliefs, originating from the SCT and TAM include those perceptions a person has about his or her ability to use computer systems and about the computer systems themselves. User Competence is a relatively new construct in literature and is introduced as a cognitive response to User Characteristics and Beliefs and an antecedent to System Use and User Satisfaction. System Use is the behavior originating SCT and explained by the TAM. System Use is the outcome anticipated from User Beliefs and User Competence and an indicator of EUC success. User Satisfaction is a person's attitude about the behavior, System Use and an indicator of EUC success. It originates from the SCT and ISSM.

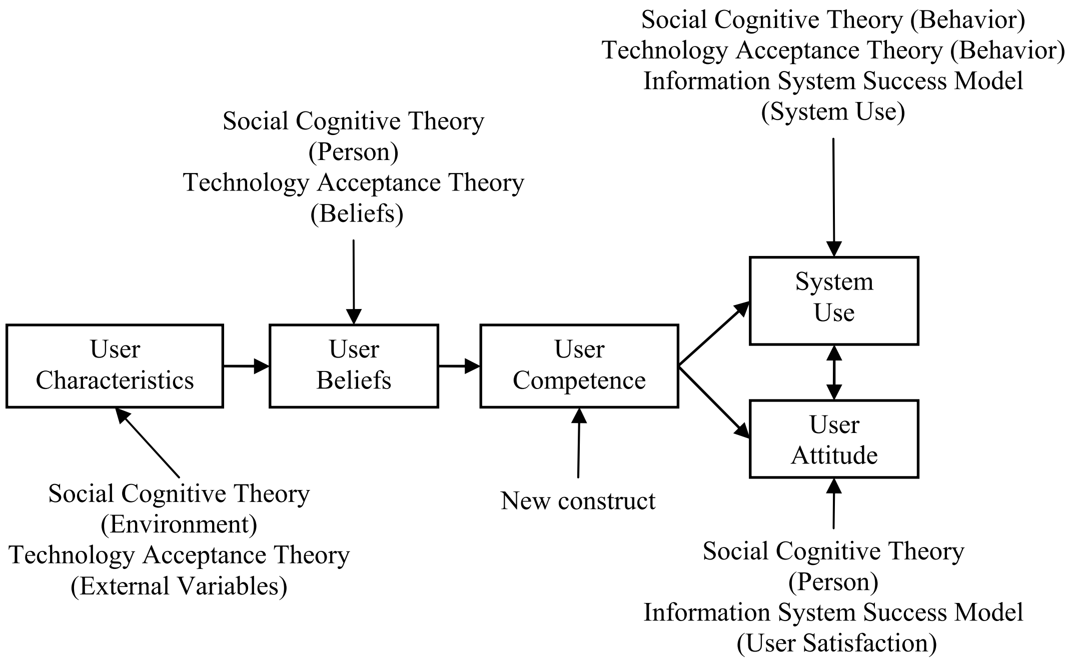

Figure 7: Conceptual Model with Construct Origins

The TAM (Davis, 1989) and SCT (Bandura, 1986) indicate that external and/or environmental variables and a person's beliefs and attitudes will impact behavior. The SCT takes this a step further with reciprocality, showing the result behavior will have on the person in the form of changes in beliefs and attitudes. Combining TAM and SCT may eliminate the limitations have on the conceptual model. The attitudinal measure, user satisfaction, is a result of the behavior, system use. Cross-referencing user satisfaction with system use acts as a check to evaluate the behavior's positive or negative impact on the person. This cross-reference compliments system use as a measure of system success in mandatory use environments (DeLone and McLean, 1992). The user satisfaction constructs verifies users are engaging in desired behavior due to system acceptance, not mandatory use.

SCT's limitation, beliefs about ability and behavioral outcomes are not enough to explain behavior, is overcome by including TAM's beliefs about the computer system itself. Users with low self-efficacy are likely not to engage in a specified behavior (Compeau, Higgins, and Huff, 1999). However, users with low self-efficacy, who also believe a system to be useful and easy to use, may be apt to attempt system use. As well, those who perceive a system less useful or difficult to use, may still be apt to use the system if users perceive they have the ability to overcome a system's shortfalls. Combining SCT and TAM, by default, includes elements of the ISSM. Recall that literature regards system use and user satisfaction as primary indicators of EUC success. By definition, User Satisfaction is the affective attitude toward system output (Doll and Torkzadeh, 1988). The behavior, System Use, and the person's attitude, User Satisfaction, are intricate parts of the ISSM (DeLone and McLean, 1992) and used throughout literature as indicators of EUC success.

As mentioned earlier, a limitation of the ISSM is a lack of accounting for users' "quality" or competence with the system. In addition, Hubona and Kennick (1996) also found that beliefs and attitudes in TAM do not fully mediate the impact external variables have on usage behavior. In a study of 225 personal computer end users in Korean businesses, Suh, Kim, and Lee (1994) concluded, "users need to learn computer concepts and techniques regarding hardware, software, and applications, in order to use information systems effectively and to be productive" (Suh, Kim, and Lee, 1994:9).

The limiting factor when integrating TAM, SCT, and ISSM comes from the need to evaluate attitudinal constructs before and after behavior. This is normally conducted by way of a longitudinal study, in which a series of measurements across time are taken,

or an experiment, in which a series of measurements are taken before and after introducing a variable. The current study is cross-sectional; a set of measurements was taken at one point in time. Since the purpose of this study is to determine the antecedents and outcomes of user competence, and while attitudes may be important antecedents of user competence, this study will only evaluate the post behavior attitude, User Satisfaction. Doing so will aid in determining whether EUC success, as determined by System Use and User Satisfaction, is an outcome of User Competence. In addition, because of the proliferation of EUC throughout society, it is assumed that all subjects of the study have already used computers and have established a degree of satisfaction toward computer systems and the information product produced.

Research Model

EUC literature indicates that antecedents of successful EUC fall into three categories: *user*, *task,* and, *organizational* (Igbaria, 1990). External variables within these categories include: age, education level, computer experience and training (user characteristics), complexity and fit (task characteristics), and user involvement and organizational support (organizational characteristics). According to TAM (Davis, 1989, 1993) and SCT (Compeau and Higgins, 1995a; 1995b), these categories impact both User Beliefs and Attitudes, which in turn impact System Use. To narrow the focus of this study, the only external variables examined are user characteristics. As discussed earlier, user attitudes are operationalized as measures after the behavior, system use.

The research model (see Figure 8) is built based on the integration of the TAM (Davis, 1989, 1993), SCT (Bandura, 1986), and ISSM (DeLone and McLean, 1992; 2002). The User Competence construct is introduced as a potential mediator between User Characteristics and Beliefs and EUC success as measured by the behavior, System Use and the attitude, User Satisfaction.

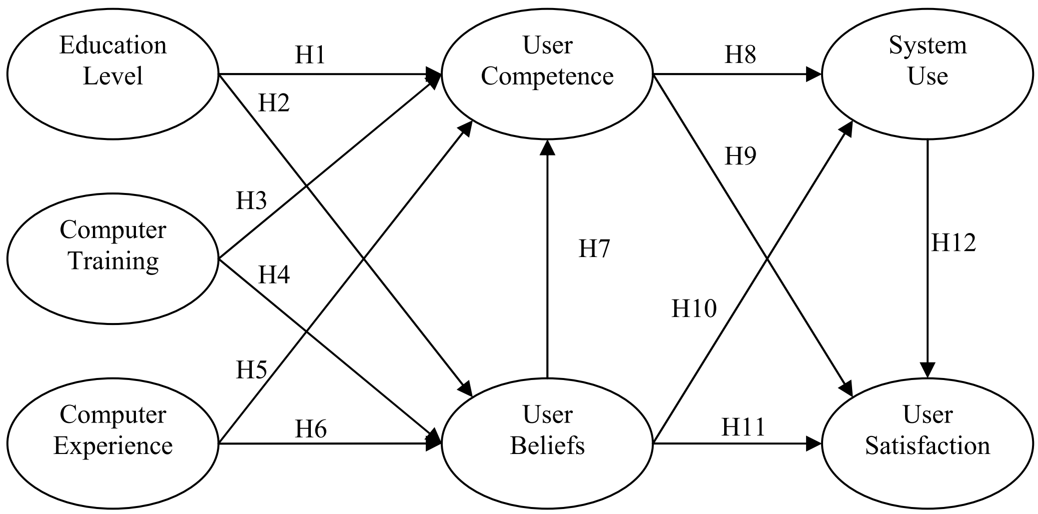

Figure 8: Proposed Research Model w/Hypotheses

Marcolin et. al. (2000) conceptualized User Competence as both a cognitive and affective outcome of learning. Learning comes about as a result of education, training, and experience (Kraiger, Ford, and Salas, 1993). A cognitive outcome is referred to as declarative knowledge gained through learning. An affective outcome is the change in attitude as a result of learning. User Competence is introduced in this model as a cognitive response influenced directly by User Characteristics and as an affective response toward System Use as influenced directly by User Beliefs (Kraiger and Ford, and Salas, 1993).

For this study, the unit of analysis is the individual; therefore focus is on individual or user characteristics. According to the SCT (Compeau and Higgins 1995a; 1995b) environmental factors impact individuals. More specifically, the TAM (Davis 1989; 1993) indicates external factors impact individual beliefs. In the context of EUC research, individual characteristics are referred to as user characteristics, the focus of this research effort. User characteristics play an important role in EUC success. Computer technology utilization depends upon ease with which technology can be operated and the confidence level individuals have using the technology (Nelson, 1991). Tay and Ang (1994) concluded that organizational and technological factors alone are insufficient; individual factors play the pivotal role in explaining user abilities and performance. The User Characteristics of interest in this study include Computer Training (Igbaria, Guimaraes, and Davis, 1995; Nelson and Cheney, 1987), Computer Experience (Rivard and Huff, 1988; Barki and Huff, 1990; Ryker, Nath, and Henson, 1997), and Education Level (Nelson, 1991) (Yaverbaum, 1988; DeLone, 1988; Al-Gahtani and King, 1999; Amoroso and Cheney, 1991; Drury and Farhoomand, 1998; Ein-Dor and Segev, 1991).

Research Questions and Hypotheses

Research Question One

Nelson (1991) found end users were deficient in their general knowledge relating to information technology. End users reported a lack of understanding of how information technology fits into an organization and information technology's potential uses. It was suggested that a lack of general and organizational education lead users to believe information technology was difficult to understand and utilize (Nelson, 1991).

Research also indicates education is related to user's computing abilities and range of computer knowledge and generic software skills. Increases in educational level may instill the belief that one can develop skills needed to utilize computer applications to complete job tasks. In addition, higher educational programs tend to provide end users with a greater number of software applications thus increasing breadth of computer-related knowledge (Igbaria, Zinatelli, and Cavaye, 1998; Tay and Ang 1994). Harrison and Rainer (1992) found that higher levels of education tended to reduce anxiety associated with computer use. Low computer anxiety is associated with highly skilled end users.

Igbaria, Guimaraes, and Davis (1995) found computer training had a direct and positive impact on user beliefs related to the computer's ease of use. Compeau and Higgins (1995a, 1995b) found computer training to be an important means of increasing the beliefs about one's ability to use a computer. Training is identified in the literature as a key factor influencing user ability and the acquisition of computer skills (Compeau and Higgins, 1995a, 1995b; Nelson and Cheney, 1987; Amoroso and Cheney, 1991). A study of 200 US Navy computer novices found that various training methods had a significant positive impact on the ability to understand the functions of computer systems (Simon, et. al., 1996).

There is a positive relationship between a user's computer background and beliefs about computer systems. Rivard and Huff (1988) reported that the quality and quantity of users' computer experience is a significant variable in explaining why some people view computers as an easy to use tool, while others view it as difficult to use. Experience in using computers may influence user competence with computer systems. In a critical

incident study of managerial end users, Tay and Ang (1994) found users had a high level of experience with generic software due to experience gained through university training and personal use. They also found that users lacked competence with customized software because of a low exposure in formal educational environments and the public domain. Igbaria and Nachman (1990) concluded that greater computer experience lead to beliefs about ease of use and greater self-efficacy, resulting in greater system use as users take the initiative to discover new ways to use the computer system. In this way, computer experience may lead to increased competence. Without a degree of user competence, exploration may be stifled. Ein-Dor and Segev (1991) found that computer use tends to decline after the first decade of computing experience. This suggests that there is a learning curve associated with computer use and that it plateaus after a decade of computer use. At the same time, the explosion of new software and hardware in the market is expanding at an exponential rate. It might be suggested that after a decade of computer use, end users have the competence necessary to apply computing knowledge and skills to new technology without increasing the amount of time spent using the system to learn new technologies.

Compeau and Higgins (1995a, 1995b) suggested that in order for individuals to develop computer skills, it may be necessary to instill the belief that the desired outcome is achievable. Achievability through ease of learning and use is a primary focus of distributed EUC (Guimaraes and Igbaria, 1997). In addition, Kraiger, et. al. (1993) indicated that individual beliefs in the ability to accomplish a certain behavior will influence that ability. Henry and Martinko (1997) also found a significant relationship between self-efficacy beliefs and users' computing ability.

In order to answer research question one; Are User Characteristics and Beliefs significant antecedents to user competence, it is necessary to look at the relationships between User Characteristics and User Competence as well as the relationship between User Beliefs and User Competence. Based the research reviewed, the following hypotheses are made in an effort to answer research question one:

H1. Education Level will positively impact User Beliefs.

H2. Education Level will positively impact User Competence.

H3. Computer Training will positively impact User Beliefs.

H4. Computer Training will positively impact User Competence.

H5. Computer Experience will positively impact User Beliefs.

H6. Computer Experience will positively impact User Competence.

H7. User Beliefs will positively impact User Competence.

Research Question Two

The model addresses EUC success in the form of computer System Use and User Satisfaction. EUC success is based on System Use and User Satisfaction (Al-Gahtani and King, 1999; Barki and Huff, 1990; Blili, Raymond, and Rivard, 1998; Compeau, Higgins, and Huff, 1999; Guimaraes and Igbaria, 1997; Gelderman, 2002). Nelson (1990) suggested that EUC success relies on the knowledge and skill level of the individual user with reference to the technology used.

Igbaria, Parasuraman and Baroudi (1996) found that users' computing skill played a significant role in computing acceptance by way of System Use. Guimaraes and Igbaria (1997) found that user computing ability was shown to impact the variety of computer-related tasks and computer use in general. Suh, Kim and Lee (1994) did a

study that empirically evaluated a causal model of EUC abilities and information system use. They obtained 225 surveys from professional, management and clerical workers in a variety of Korean-owned businesses. They concluded that EUC abilities positively impact computer use and a certain level of EUC ability is essential for EUC success.

A major objective in the design and implementation of successful EUC is end User Satisfaction. This is based on the assumption that a satisfied end user will be a productive employee (Yaverbaum, 1988).

H8. User Competence will positively impact System Use.

H9. User Competence will positively impact User Satisfaction

Additional Relationships

There are additional relationships believed to be present in the model based on previous literature, but not associated with a research question. To create the best-fit model, these relations are included and hypotheses are formed in an attempt to validate previous findings from previous research in the AF population.

User Beliefs are defined as an individual's subjective probability that performing a specific behavior will result in expected outcomes (Davis, 1989; Davis et. al., 1989). Beliefs about computers are determined by the perceived ease of use and usefulness of a computer, as well as the level of self-efficacy one has about his or her abilities to use a computer (Compeau and Higgins 1995a, 1995b; Compeau et. al., 1999; Davis, 1989; Davis et. al., 1989). Hence, an individual, confident in his/her ability to operate a system perceived as useful and easy to use in accomplishing tasks will readily increase their competence to use the system successfully. As the perceived functionality of a computer system increases, perceived usefulness and ease of use beliefs have strong positive

impacts on system use (Igbaria et.al., 1995; Igbaria et. al., 1997). As well, Bandura (1986) indicates that self-efficacy plays a role in affecting motivation and behavior. Abilities are a key to individual performance and the pursuit of better performance impacts individual cognation and behavior.

The Theory of Reasoned Action (Ajzen and Fishbein, 1980), on which the TAM model is based, indicates that the beliefs are important determinants of user attitudes. Attitudes are influenced indirectly through changes in a person's belief structure (Ajzen and Fishbein, 1980). Davis (1993) suggested that believing a system to be useful to accomplishing ones tasks and easy to use will influence attitudes about the system. In addition, Compeau and Higgins (1995a) found beliefs about one's ability to use a computer to significantly impact both negative and positive attitudes.

Igbaria and Nachman (1990) found a strong positive correlation between System Use and User Satisfaction. As a result of additional use, system familiarity enhances users' satisfaction resulting in the motivation to find new ways to use the system. Finally, Gelderman (2002) conducted a study in which he found a significant link between System Use and User Satisfaction.

The following hypotheses are based on relationships outlined in literature and are present in the research model:

H10. Users' Beliefs will positively impact System Use.

H11. Users' Beliefs will positively impact User Satisfaction

H12. System Use will positively impact User Satisfaction.

Research Question Three

In order to establish whether or not the AF is positioned to practice successful EUC now and in the future two issues will need to be evaluated.

First, it must be determined whether or not the AF organization is currently practicing successful EUC. Two primary factors which literature has established as indicators used to evaluate EUC success are the System Use construct and the attitudinal measure, User Satisfaction. EUC success occurs when scores for both System Use and User Satisfaction are above the population mean. Scores lower than the population mean of either or both of these factors indicates less than optimal utilization of EUC resources and may be an indication that additional resources are needed to establish EUC success. For the AF organization to be practicing EUC success, a significantly higher number of users should be found maximizing computer system use and be satisfied with the computer system and its information product.

Second, to see whether or not the AF organization is prepared for future EUC success, the current level of user computing competence should be determined. The factors which previous research has established to evaluate User competence are its measures: breadth, depth and finesse. Breadth and depth evaluate users' current knowledge about computer systems while finesse evaluates the users' ability to apply that knowledge to solve job related problems or complete unfamiliar job related tasks. It can be theorized that an organization is best prepared for current and future computing success when users have the ability to apply computer related knowledge to unfamiliar tasks or problems and have high levels of breadth and depth of knowledge about current computing technology to draw from. Any of the three factors with a score lower than the

population mean may indicate users are unprepared to efficiently and effectively complete current and future computer-related job tasks. Low scores may also be an indication that additional resources are needed to bring computing competence levels to a level high enough to effectively and efficiently accomplish computer related job tasks. For the AF organization to be practicing EUC success, a significantly higher number of users should be found with high scores in all three measures of User Competence: breadth, depth, and finesse.

Based on the need to have a higher proportion of end users currently involved EUC success and prepared for future EUC success, the following hypotheses are proposed:

H13. The proportion of end users involved in successful EUC is greater than those involved in unsuccessful EUC.

H14. The proportion of end users highly competent is greater than those at lower levels of competence.

Summary

The purpose of this research is to discover the antecedents and outcomes of User Competence. It is hoped that the determinants of EUC success, System Use and User Satisfaction are outcomes of User Competence. Understanding this, programs can be put in place which will manipulate the antecedents of User Competence, allowing it to grow and expand, taking full advantage of the capabilities EUC has to offer today, and preparing end users to adapt to new technology rapidly as it becomes available. Using

technology to its full extent and obtaining a high level of satisfaction with computer systems and its information product will lead to EUC success.

III. Methodology

Overview

The preceding chapters discussed the current state of the end user computing arena and characteristics end users should possess to increase computing success. The theory brought forward is that end users, whose job tasks are reliant on computers, will use computers successfully when their competence levels increase as a result of additional training, education, and experience. This chapter will outline the methodology used to investigate the research hypotheses proposed in Chapter II. It includes a description of the population, data collection techniques, survey instrument development and administration, and the statistical techniques used to analyze the data collected.

Research Approach

This is a cross-sectional study using survey data to determine antecedents of User Competence and discover whether or not EUC success is an outcome of User Competence. The survey data is evaluated to test the seven hypotheses associated with research question one, the two hypotheses associated with research question two, and three additional hypotheses identifying additional relationships in the model outlined in Chapter II. Hypothesis testing for research question one and two is conducted using structural equation modeling (SEM) with the LISERL 8.52 (Jöreskog and Sörbom, 2002) software package. Hypotheses testing for research question three will require two chi-squared tests of independence. The first will determine if each of the factors of EUC

success is independent of each other and the second will determine if each of the factors of User Competence is independent of one another.

Relevant Population

The population selected for this research is comprised of military and civilian end users assigned to the Aeronautical Systems Center (ASC) organization at Wright-Patterson Air Force Base (WPAFB), OH. End users were determined by identifying valid email accounts. Using email accounts to determine end users, IT/IS employees are also included in the population, contrary to the definition of an end user in Chapter I. IT/IS employee data collected in the sample was removed prior to data analysis. The study will also exclude Senior Executive Schedule (SES) civilians, military Generals (O-7 to O-10), contractors, members from sister services, and foreign nationals. Excluding these personnel will ensure the study focuses on those employees with which AF computer training and educational programs are also focused. Also excluded are the specialty skilled Wage Grade (WG) employees. These employees possess specialized skills unrelated to computers. Their use of computers in relation to job performance is minimal.

As recommended by Shayo, Guthrie, and Igbaria (1999), the context of computer use among end users needs clarification. Two government acts were passed in part to ensure, "that information technology is acquired, used, and managed to improve performance of agency missions…" (The Paperwork Reduction Act (PRA), 1995) and "the acquisition and use of information technology…that provide for electronic submission, maintenance, or disclosure of information as a substitute for paper and for

the use and acceptance of electronic signatures"(Government Paperwork Elimination Act (GPEA), 1998). The passage of these acts translates to mandatory IT use within federal agencies, to include the AF. Information systems such as the Automated Base Supply System (ABSS) and LeaveWeb, are examples of computer-based systems that have replaced paper-based systems, forcing personnel to use these systems. Unit commanders have, in some instances, mandated all personnel in the unit read and respond to email received at least once per workday. For the purpose of this study, the use of computer systems is considered mandatory.

Data Collection Method

Surveys are a common method of gathering large amounts of data from large populations at minimal cost to the researcher. In this study, the population is based on the number of ASC members with email accounts. Ensuring individuals in the population have email accounts; it is assumed these same individuals work with computer systems on a regular basis. To collect data for this survey, email messages describing the study and containing a hyperlink to the web-based survey were used. Because our society hails the virtues of computers, it is not always acceptable to readily admit competence or incompetence with computers (Tay and Ang, 1994). Therefore, referring to "user competence" in the survey name was avoided by naming the survey "The User Effectiveness Survey" in an attempt to reduce bias against the survey. It was feared some recipients of the email message might be offended by questioning their competence with computer systems.

According to the findings of Franke (2001), the use of a web-based survey verses paper-based survey appears to be just as valid as long as no sensitive data is collected. The User Effectiveness survey requests no sensitive or identifying data from participants. Respondents remain anonymous throughout the data collection process. Therefore, in this instance, the most appropriate and cost effective way to quantitatively collect data for this research effort is through a web-based survey.

Survey Development

The survey instrument for this study is based on the user competence framework established by Munro, et. al.(1997) and discussed in Chapter II. To enhance reliability and validity, all measures used in this study are adapted from existing instruments. DeLone and McLean (1992) endorse this method as it creates well developed and tested measures to establish credible findings in information technology studies. Measurement constructs are discussed in the following sections. Screen shots of the complete survey are found in Appendix A.

User Competence

The User Competence construct was operationalized through the development of a 3-dimensional User Competence Framework (Marcolin, et. al., 2000). The researchers compiled literature relevant to the study of EUC and developed the User Competence Framework as a basis for future research. For this study a self-report method of measurement is used to identify affective and cognitive concepts of competence in three distinct computing knowledge domains: software, hardware, and concepts and policies. The three dimensions of user competence were measured using an adapted version of the

survey instrument used by Munro, et. al.(1997). Upon request, Barbara Marcolin provided an electronic copy of the instrument used in the Munro et. al. (1997) study. The measures of *breadth*, *depth*, and *finesse* were taken across the three knowledge domains (hardware, software, and concepts and policies).

Breadth (BR) - The breadth measurement was assessed on a single scale. The subject was asked to respond to five items assessing the range of knowledge (1=narrow to 7=broad) they had about computer software, hardware, concepts, programming languages, and overall computing as compared to other employees within the organization (Munro, et. al., 1997).

Depth (DEP) - The depth measurement was assessed on a single scale. The subject was asked eight items assessing the thoroughness (8-point Likert scale; 0=no knowledge to 7=complete knowledge) of his/her current knowledge about computer software, hardware, concepts, principles, security, and overall computing (Munro, et. al., 1997).

Finesse (FIN) - Through interviews and discussions with users in the field and an IS academic panel, Munro et. al. (1997) characterizes finesse using three terms:

1. Creativity – to find new ways to apply computing tools to solve problems
2. Self-sufficiency – to function without extensive help to solve computing problems
3. Ability to learn – to easily discover and learn capabilities of computing tools

Based on these abilities, subjects were asked to respond to five survey items assessing the frequency (5-point Likert scale; 1=rarely to 5=often) with which he/she creatively and innovatively make use of computing tools at their disposal (Munro, et. al., 1997).

User Beliefs

Self-efficacy (SE) - Self-efficacy was measured using the ten-item scale developed and tested by Compeau and Higgins (1995a, 1995b). References to "similar software packages" were dropped to avoid bias based on comparisons between software packages. The remaining eight-item scale required subjects to consider whether they could complete a job task using unfamiliar software computing tools with varying degrees of assistance available. First, the subjects were asked if they could complete the task, yes or no. If yes, they were asked how confident (10-point Likert scale; 1=not confident to 10=very confident) they were that the task would actually be completed. Subjects answering “no” to whether or not they thought the task could be completed, were assigned “0” confidence.

Perceived Ease of Use (PEOU) - Davis (1989) established perceived ease of use as a meaningful measure in the study of information technology use. Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989:320). Based on his findings, a five-item scale for PEOU was selected. Subjects responded with the degree to which they believed a computer system was easy to use (5-point Likert scale; 1=strongly disagree to 5=strongly agree).

Perceived Usefulness (PU) - In the same study, Davis (1989) also established perceived usefulness as a meaningful measure in the study of information technology use. Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989:320). Subjects were asked to respond with the degree to which they believed a computer

system would be useful performing job tasks (5-point likert scale; 1=strongly disagree to 5=strongly agree).

User Characteristics

Computer Training 1 (TR1) - Subjects were asked to report the number of courses completed or self-taught in 17 subject areas within the computing knowledge domains. Munro, et. al. (1997) used a similar technique to evaluate training. The total number of courses completed/self-taught by subject area is observed variable TR1.

Computer Training 2 (TR2) - Subjects were asked to report the number of courses taken from different sources: AF organization, third-party/vendor, self-studied, and other sources of computer related training. Amoroso and Cheney (1991) used a similar technique to evaluate training.

Computer Experience (EXP) - Subjects were asked to report a single item indicating the number of years they had used computers in the workplace.

Education Level (EDU) - The subjects were asked to report the highest educational level completed. Six levels of education were identified (1 to 6): high school diploma, vocational/technical school certificate, associates' degree, bachelors' degree, masters' degree, and doctorial degree. The education level scores were re-coded to reflect the generally accepted number of years it took to achieve each level (Table 1).

Table 1. Education Level Coding

Original Score	Education Level	New Score
1	High school diploma	12
2	Vocational/Technical school	13
3	Associates' degree	14
4	Bachelors' degree	16
5	Masters' degree	18
6	Doctorial degree	21

System Use

System Use is a self-reported measure of actual computer use, a method adopted by several researchers (Davis, et. al., 1989; Igbaria, 1990; Amoroso and Cheney, 1991; Torkzadeh and Dwyer, 1994). Four primary System Use measures were found in the literature (Igbaria, et. al., 1989; Davis et. al. 1989; Thompson, Higgins, and Howell, 1991; Igbaria, 1993). These measures are single items and were adapted for this study as described below.

<u>Frequency of use (FREQ)</u> - This measure was originally scaled from 1 (less than once a month) to 5 (at least once per day). Because of the proliferation of computer systems and government regulation mandating the use of information technology, the scale was adjusted. Measured on a 5-point scale from 1 (less than once a week) to 5 (several times a day), it requests the subjects to report how often a computer was used in the workplace.

Time of use (TIME) - Measured on a 5-point scale from 1 (less than 1 hour per day) to 5 (4 hours or more per day) it requests the subjects to report the amount of time a computer was used on those days it was used.

Variety of use (APPS) - Measured on a 5-point scale from 1 (one application) to 5 (5 or more applications) it requests the subjects to report the number of software applications accessed on those days a computer is used.

Variety of tasks (TASK) - Measured on a 5-point scale from 1 (one task) to 5 (5 or more tasks) it requests the subjects to report the number of job-related tasks completed on those days a computer is used.

User Satisfaction

User Satisfaction (SAT) - User satisfaction is the affective attitude towards a computer product by an end user who interacts with the computer system directly (Doll and Torkzadeh 1988). They developed and tested a 12-item instrument measuring user satisfaction. Their results suggest that the instrument is both valid and reliable. Doll, Xia, and Torkzadeh (1994) rigorously re-validated and enhanced the user satisfaction instrument by providing confirmatory factor analysis evidence that showed that the 12-item instrument measures and explains the user satisfaction construct.

Demographics

The following self-reported demographic information was also collected:

Career Field (JOB) - Military personnel responded with their AF specialty code (AFSC); civilians responded with their career program identifier.

Rank/Grade (RANK) - Nine categories were established to encompass individuals in the population for which this study was intended: E-1 to E-4, E-5 to E-6, E-7 to E-9, O-1 to O-3, O-4 to O-6, GS-1 to GS-5, GS-6 to GS-10, GS-11 to GS-14, and Others.

Time in AF (YRSAF) - Number of years employed by the AF.

Time in Job (YRSJOB) - Number of years assigned to AFSC/Career program.

Age (AGE) - Age of respondent in years.

Gender (GEN) - Gender of respondent.

Table 2 summarizes the sources of the measurement scales found in this study and Figure 9 shows the observed and latent variables of the proposed research model to be tested.

Table 2: Summary of Measures

Measure	Abbreviation	# Items	Source
Breadth	BR	5	Munro, et. al. (1997)
Depth	DEP	8	Munro, et. al. (1997)
Finesse	FIN	5	Munro, et. al. (1997)
Perceived Ease of Use	PEOU	5	Davis (1989)
Perceived Usefulness	PU	6	Davis (1989)
Self-Efficacy	SE	8	Compeau et. al. (1999)
Training1	TR1	17	Munro, et. al. (1997)
Training2	TR2	4	Amoroso and Cheney (1991)
Frequency	FREQ	1	Thompson et. al. (1991) and Igbaria (1990; 1993)
Time	TIME	1	Thompson et. al. (1991) and Igbaria (1990; 1993)
Applications	APPS	1	Thompson et. al. (1991) and Igbaria (1990; 1993)
Tasks	TASK	1	Thompson et. al. (1991) and Igbaria (1990; 1993)
User Satisfaction	SAT	12	Doll and Torkzadeh (1988)

APPS – applications
BR – breadth
DEP – depth
EDU – education
EXP – experience
FIN – finesse
FREQ – frequency
PEOU – perceived ease of use
PU – perceived usefulness
SAT – user satisfaction
SE – self-efficacy
TASK – tasks
TIME – time
TR1 – training1
TR2 – training2

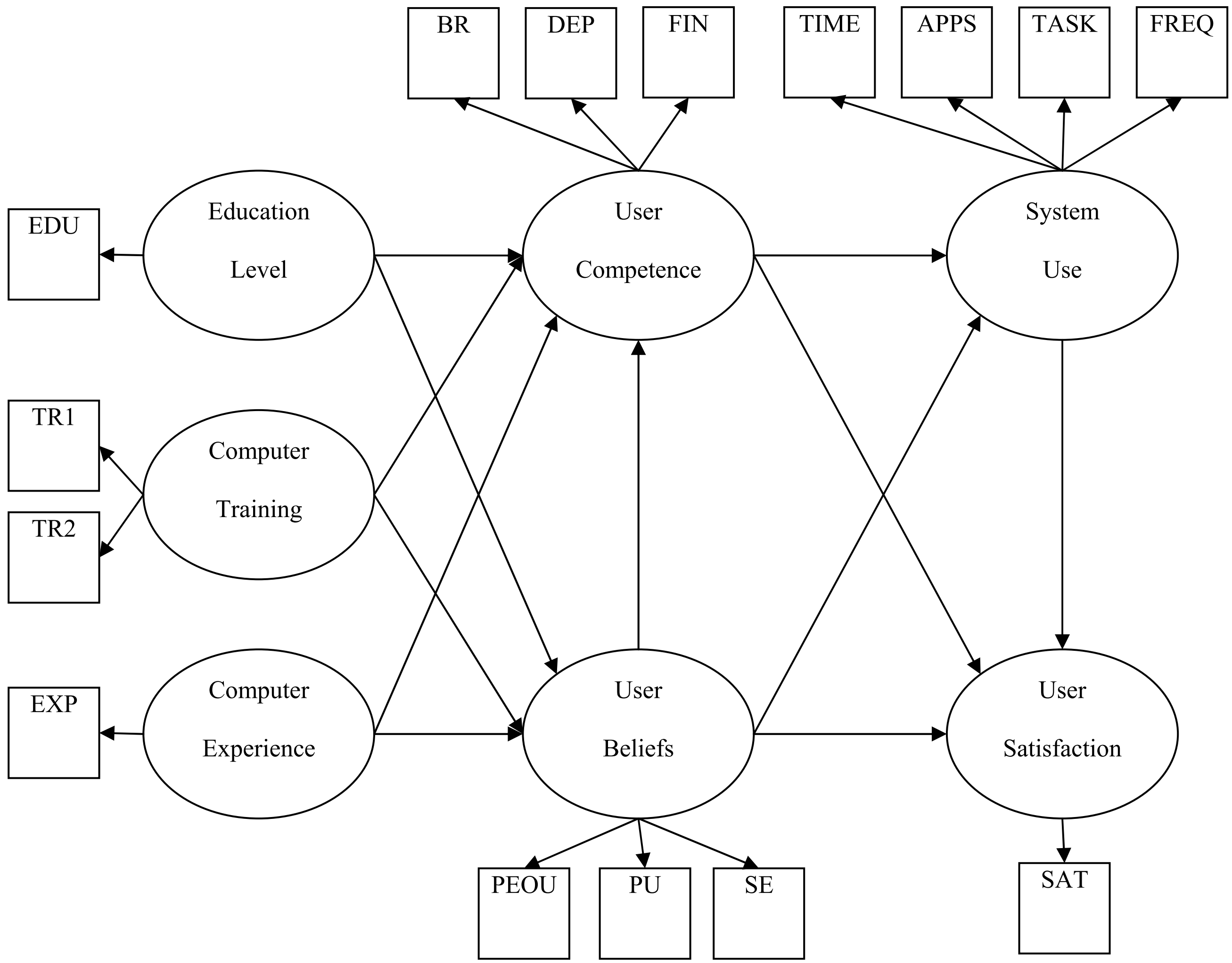

Figure 9: Proposed Research Model w/Measures

Survey Modification

Once all questions for the survey were established and adopted for the population of interest and subject matter, the User Effectiveness survey (UE) survey needed validation and approval. The UE survey was presented to two faculty members to ascertain its validity. Both agreed it contained face validity and recommended re-wording some questions to avoid ambiguity and provide a frame of reference for the survey participants.

Next, the Air Force Institute of Technology Communications section (AFIT/SC) converted the paper-based UE survey into a web-based survey by Anthony Maddin, contractor, using Cold Fusion programming software. It was then hosted on AFIT's School of Engineering and Management web server and given an address of http://en.afit.edu/env/user_effectiveness/default.htm. A Microsoft Access database was integrated with the UE survey website to capture data inputted by survey respondents. The opening page for the UE survey gave respondents the choice of reading the survey instructions or moving straight to the survey. The data collection portion of the survey consisted of 7 sets of questions, totaling 85 items requiring 135 responses. The survey was programmed in such a way as to require all response items in a section be completed before moving on to the next section. It was estimated the survey would take 15 minutes to complete. The UE survey was now classified as an on-line data collection instrument as defined by Dooley (2001).

As part of the on-line UE survey validation and testing, a pretest of the survey instrument and database was conducted. An email was sent to 46 Information Resource

Management graduate students attending AFIT on 28 Oct 02. The point of contact for ASC/HR, Mr. John Spain, was also included in the pre-test. The message requested pretest participants follow a hyperlink to the UE survey and provide input as to the clarity, usability, and soundness of the survey. Input received suggested some questions be clarified, additional instructions be added, and the overall length of the survey be reduced. Additional instructions and definitions were added to the survey website for clarification purposes. Several programming errors between the survey website and collection database were discovered and corrected during this phase as well.

Survey Approval

The intent of this study was to survey members of the Aeronautical Systems Center (ASC) as part of ASC's Human Resource's (HR) Information Technology Reskilling efforts. Per Air Force Instruction 36-2601 (HQ/AFPC, 1996), surveys conducted at the base level need only the commander's approval. In addition, permission from the local union is required when including civilian AF employees as part of the study. The ASC/HR points of contact were Ms. Sherri Collier and Mr. John Spain. Ms. Collier and Mr. Spain each received an initial hard copy of the UE survey instrument on 11 Oct 02. Ms. Collier coordinated with ASC leadership and received approval from Lieutenant General Richard Reynolds, ASC commander, on 5 Nov 02. Mr. Spain worked with Mr. Brian Normlie of the WPAFB Civilian Personnel office to obtain approval from the American Federation of Government Employees (AFGE) to conduct the survey. On 22 Oct 02, Ms. Pam McGinns, president of AFGE local 1138, granted approval via an email message to Mr. Normlie.

Additionally, a request to conduct the UE survey on human subjects was sent to the Human Subjects Board, run by the Air Force Research Laboratories at Wright-Patterson Air Force Base. A letter of approval was received, after the fact, on 26 Nov 02.

Pilot Test

Once permission to conduct the UE survey was granted by ASC and union leadership, a pilot test was initiated. On 11 Nov 02, a notification email was sent to100 randomly selected ASC computer users. Of the 100 emails sent, 6 were returned as "undeliverable" due to an unrecognized address or account owner not available for delivery. No errors were found when the email addresses were reverified. The explanation for unrecognized addresses may be due to the fact the Global Address Listing (GAL) from which the email addresses were obtained was almost two months old. The total number of completed deliveries was 94, for a 94% delivery success rate.

Initially, 29 responses were recorded in the collection database. Of these, 11 were unusable. Thus, a return rate of 19 percent was achieved based on 94 potential respondents. Although only 18 usable responses were received, a factor analysis with varimax rotation was performed on the 18 user competence items in the survey. The user competence items loaded on 3 factors, which is what was expected, based on the three independent dimensions of user competence. The reliability of breath, depth and finesse, based on the Cronbach alpha measurement was .81, .78, and .91, respectively. Nunnally (1978) established that a Cronbach alpha measure greater than .70 is acceptable for reliability.

These findings were viewed with caution, as there were only 18 sampling points. Because of the low usable response rate and the fact that the other scales used in the survey were from previously validated studies, no other preliminary analysis was conducted. During the final survey, additional follow-up messages were sent to encourage a higher level of participation. It was anticipated that this would increase the expected return rate to 30%, the amount considered appropriate for academic rigor. Because of the low return rate during the pilot study, no factor analysis was done to reduce the size of the survey.

Sample Size

Guidance from AFIT's survey manager, Ms Beverly Houtz, indicated that survey sample sizes should remain under 1000 to reduce the impact a survey has on the work environment. Therefore, rather than sampling the entire population of interest, the following formula was used (Air University, 1996) to establish a required sample size needed to achieve a 99% confidence interval for the study.

$$n := \frac{N \cdot (Z)^2 \cdot p \cdot (1-p)}{(N-1) \cdot d^2 + Z^2 \cdot p \cdot (1-p)} \tag{1}$$

Where:
n = required sample size
N = population (3878)
p = maximum sample size factor (.25)
d = desired tolerance (.05)
z = factor of assurance (2.326)

Applying the formula to the data for this study, an n = 367 was determined as the minimum number of usable survey responses needed to achieve a 99 percent confidence interval. Next, the number of email notifications required to acquire a sample size of 367

usable surveys must be calculated. Based on an anticipated notification failure rate of 10% (due to the age of the GAL) and an expected return rate of 30% (increased over pilot test because of follow-up message), the following formula is used:

$$s := \frac{n \cdot f + n}{r} \tag{2}$$

Where: n = required sample size (367)
f = notification failure rate (10%)
r = expected return rate (30%)
s = number of email notifications

Applying the formula to the data for this study, an s = 1345 was determined. The figure was rounded up to s = 1400 was considered the minimum number of email notifications that needed to be sent out to ensure the minimum number of usable responses were received. The mathematical evidence shows that the figure of 1000 given as guidance from AFIT's survey monitor was unrealistic if the findings in this study are to uphold standards of academic rigor.

Survey Administration

Survey notification to 1400 members of the population was made on 12 Nov 02 via email. Members were selected from the population using random sampling. Addresses were generated from the GAL provided by Lori Gilbert of AFIT's communications support office. The researcher's personal email account was used to deliver the notifications. All email notification failures were delivered to this account and monitored by the researcher. The text of the notification message (see Appendix B) explained that the survey was being conducted by the Air Force Institute of Technology to measure user effectiveness in the application of computing resources. The message

also stated that the survey had been approved by ASC and AFGE leadership, was voluntary, and anonymous. The web-based survey was hosted on an AFIT web server at the address http://en.afit.edu/env/user_effectiveness/default.htm.

The initial notification failure rate was 4.21 percent. This was better than the anticipated 10 percent delivery failure rate. Once notifications were made, two information assurance shops and several individuals requested additional information to identify the survey as valid and not a threat to network security. In response, the researcher provided the names of the points of contact at ASC , Ms Sherri Collier and Mr. John Spain, and re-stated that the survey was approved by ASC and AFGE leadership. In addition, several participates indicated that the survey website was malfunctioning, not allowing them to move on to the next section. It was determined that the participants were not completing all questions before moving on to the next section. Therefore, a second message to all participants was sent on 13 Nov 02, re-iterating that all questions in each section must be answered before moving on to the next section. To increase survey response rate, a third message was sent on 19 Nov 02 reminding and urging participants to complete the survey if they had not already done so. The survey results were collected from the database on 25 Nov 02.

Statistical Analysis

As discussed in Chapter II, the goal of this research effort is to establish the antecedents and outcomes of the user competence construct. To determine an appropriate analytical method, the characteristics of the research model must be taken into account. The first characteristic is the number of dependent variables, in this case four.

Additionally, several latent variables have multiple observable measures assigned. In the proposed model (Figure 9) there are 11 observable measures loading on 4 dependent latent variables. Finally, the model evaluates the mediating relationship between latent variables. Structural equation modeling (SEM) was recommended by the research committee and selected based upon SEM's ability to accommodate these requirements (Jöreskog and Sörbom, 1993). SEM will be used to test hypotheses one through twelve outlined in Chapter II in an effort to address research questions one and two.

To determine whether the AF is positioned for successful end user computing, two contingency tables are developed. The first will cross-reference high/low scores of factors considered necessary to EUC success and the second will cross-reference high/low scores of the User Competence factors. To obtain a single score for System Use, the mean value of its measures is used. The chi-squared test for independence is used to determine if there is a significant difference in the proportion of successful verses unsuccessful computer users and competence verses non-competence users. Using the probability of EUC success as an example, the following null hypothesis is presented:

Ho: $P(S) = P(S|U) = P(S|U')$

$P(S)$ is the probability of high System Use. $P(S|U)$ and $P(S|U')$ are conditional probabilities of high System Use given that the respondent was satisfied or not with the system use. Failing to reject the null hypothesis implies there is no statistical difference between the proportions of users in each EUC status classification (successful and unsuccessful). The alternative hypothesis, then, is at least one other conditional probability is different from the others. A similar chi-squared test for independence is used to test levels of User Competence. For the AF to be positioned for computing

success, a significant number of participants should be successful computer users with a high level of competence.

Summary

This chapter described the research design and methodology used to measure the user competence of ASC computer users and factors which may impact user competence. The research goal is to determine if, as hypothesized, the factors identified are antecedents of User Competence and factors that determine EUC success are outcomes of User Competence. The following chapter discusses the analysis of the survey data. Results of the data analysis will be discussed in Chapter V along with the, implications for the Air Force, limitations of the research, and suggestions for further study.

IV. Analysis

Overview

The survey was designed to collect data for the purpose of determining if User Characteristics and Beliefs are antecedents of User Competence, which in turn is an antecedent for System Use and User Satisfaction, determinants of EUC success. The conceptual model was established by integrating elements from the Social Cognitive Theory (SCT), the Technology Acceptance Model (TAM) and Information Systems Success Model (ISSM). The SCT determines perceptions about behavioral outcomes and user abilities to affect behavior as determinants of learning. TAM establishes beliefs and attitudes as determinants of behavior. ISSM provides the basis for end user computing (EUC) success by showing the need to measure both behavior and attitudes. Since attitudes can not accurately be measured before and after behavior during a cross-sectional study, only those attitudes related to post behavior are evaluated.

This chapter evaluates the three research questions and twelve hypotheses using data collected by the User Effectiveness survey. First, the results of administering the survey are provided along with demographic and descriptive statistics for the observed variables found in the model. Second, the validity and reliability of the measured variables is established. Next, research questions one and two, along with their associated hypotheses, are evaluated using structural equation modeling (SEM) as contained in the LISREL 8.52 software package (Jöreskog and Sörbom, 2002). The final research question is answered using chi-squared tests to evaluate the associated hypotheses referencing levels of user competence and EUC success.

The study population only consisted of ASC members with email accounts listed on the GAL as of September 2002. The purpose of Table 3 is to show the random selection of samples produced accurate reflections of the population. The population consists of approximately one-fourth military members and three-fourths civilian members. Both samples are consistent with this distribution. Note that undelivered emails requesting survey participation was somewhat higher for military members. This is expected due to the deployable and mobile nature of military members' lifestyle.

Table 3: Population and Sample Distributions

Group	Population		Pilot Sample				Study Sample			
			Sent		Undelivered		Sent		Undelivered	
	#	%	#	%	#	%	#	%	#	%
Military	974	25.72	28	28.00	4	16.67	371	26.50	35	9.43
Civilian	2,813	74.28	72	72.00	2	2.78	1,029	73.50	24	2.33
Total	3,787	100.00	100	100.00	6	6.00	1,400	100.00	59	4.21

Table 4 shows the response rate of the pilot and study samples. For the study sample, of the original 1400 survey notifications sent out, 59 were never delivered and 542 subjects responded. Of the 542 subjects that responded, 127 were unusable for the following reasons: 94 incomplete surveys; 23 identified rank as “other”- indicating they did not fit into the study population; 5 indicated no rank, education, and/or age values; 5 were IT/IS professionals - did not fit the definition of an end user.

Table 4: Response Rate Summary

Response Category	Pilot #	Pilot %	Study #	Study %
Sent and Received	94	94.00	1341	95.79
Returned	29	30.85	542	40.42
Unusable	11	11.70	127	9.47
Usable	18	19.15	415	30.95
No Response	65	69.15	800	59.66

The high number of incomplete surveys was due, in part, to unclear instructions. Several participants emailed the researcher indicating the survey website was not allowing them to submit their responses. Investigating the problem with AFIT web support personnel, it was determined the participants were not answering all questions in each section before moving to the next section. An email was sent to all participants clarifying the instructions and that all questions must be answered before submitting responses and moving on to the next section. Because of the high response rate, this technical difficulty was not seen as having a significant impact on the study.

The 415 usable surveys indicate a return rate of almost 31%. The higher response rate from the study sample was due to an additional email reminding subjects to complete the survey and additional time allocated to do so. Table 5 is included here as a demographic representation of the subjects participating in the study. The responses included 31.3% military members and 68.7% civilian members. The expected response distribution was 25% military and 75% civilian. This indicates the possibility of non-

response bias in civilians and/or response bias in military members. Other demographic breakdowns were consistent with expectations.

Table 5: Demographic Summary

Category	Military #	Military %	Civilian #	Civilian %	Total #	Total %
Education	*Average*	*16.79*		*16.35*		*16.49*
High School	6	4.62	32	11.23	38	9.16
Tech/Voc School	3	2.31	6	2.11	9	2.17
Associates Degree	6	4.62	17	5.96	23	5.54
Bachelors Degree	50	38.46	104	36.49	154	37.11
Masters	59	45.38	116	40.70	175	42.17
Doctoral Degree	6	4.62	10	3.51	16	3.86
Gender						
Male	113	86.92	178	62.46	291	70.12
Female	17	13.08	107	37.54	124	29.88
Age	*Average*	*34.02*		*45.47*		*41.88*
18 to 24	21	16.15	11	3.86	32	7.71
25 to 29	19	14.62	14	4.91	33	7.95
30 to 34	30	23.08	6	2.11	36	8.67
35 to 39	21	16.15	18	6.32	39	9.40
40 to 44	26	20.00	75	26.32	101	24.34
45 to 49	10	7.69	59	20.70	69	16.63
50 to 54	1	0.77	64	22.46	65	15.66
55 to 59	2	1.54	25	8.77	27	6.51
60 to 64	0	0.00	10	3.51	10	2.41
65+	0	0.00	3	1.05	3	0.72

Category	Military #	Military %	Civilian #	Civilian %	Total #	Total %
Years in AF	*Average*	*11.29*		*19.57*		*16.98*
0 to 4	38	29.23	32	11.23	70	16.87
5 to 9	19	14.62	14	4.91	33	7.95
10 to 14	18	13.85	18	6.32	36	8.67
15 to 19	34	26.15	67	23.51	101	24.34
20 to 24	17	13.08	63	22.11	80	19.28
25 to 29	4	3.08	52	18.25	56	13.49
30+	0	0.00	39	13.68	39	9.40
Years in Job	*Average*	*6.22*		*12.53*		*10.55*
0 to 4	73	56.15	73	25.61	146	35.18
5 to 9	19	14.62	46	16.14	65	15.66
10 to 14	18	13.85	41	14.39	59	14.22
15 to 19	15	11.54	55	19.30	70	16.87
20 to 24	4	3.08	41	14.39	45	10.84
25 to 29	1	0.77	14	4.91	15	3.61
30+	0	0.00	15	5.26	15	3.61
Career Field						
Acquisition	58	44.62	36	12.63	94	22.65
Analyst	0	0.00	14	4.91	14	3.37
Clerical	0	0.00	13	4.56	13	3.13
Contracting	11	8.46	49	17.19	60	14.46
Engineering	22	16.92	83	29.12	105	25.30
Financial	16	12.31	44	15.44	60	14.46
Management	0	0.00	22	7.72	22	5.30
Other	23	17.7	24	8.42	47	11.32
Total	*130*	*100.00*	*285*	*100.00*	*415*	*100.00*

Validity and Reliability

As suggested by DeLone and McLean (1992) all measurement scales were adopted from previously published studies to assist in establishing traditional measures for studies of end user computing. Table 2 in Chapter III summarizes the source of the scales used in this study. Measurement scales consisting of more than one item were, with the exception of TR1 and TR2, were verified for validity and reliability. The items constituting TR1 and TR2 were not factor analyzed or checked for reliability. These items are self-reported counts of training events. TR1 consisted of seventeen questions asking how many computer-related training events, broken down by software and hardware platforms had the participant attended. TR2 consisted of four questions asking about the source of the training, such as self-taught or AF provided. It is understood that these items are measuring different factors (hardware, software, self-taught, or AF provided), however, it is the computer-related training event that is important to the study rather than the specific subject matter. In addition, TR1 and TR2 violate normality assumptions needed to perform validity and reliability tests (see Table 8). When requesting self-reports of training events, researchers must rely on the accuracy of the participant's memory. These items are assumed to be valid and reliable measures of computer related training.

Factor Analysis

A series of factor analyses were performed on the seven multi-item measures found in the proposed research model: breadth (BR), depth (DEP), finesse (FIN), perceived ease of use (PEOU), perceived usefulness (PU), Self-efficacy (SE), and Satisfaction (SAT) to establish construct validity of the measures. It is expected that

these seven measures will load on to three latent variables, User Competence, User Beliefs, and User Satisfaction.

An initial factor analysis was performed on all items. This first run revealed two items from the DEP scale loaded on a separate component and one item from the PEOU scale loaded with a negative inter-item correlation. These items were removed and a second factor analysis was performed.

The second run revealed two items from SE cross-loaded with another component. These items were removed. In addition, this run also revealed that all PEOU items were loading relatively weak. Each item showed less than .70 inter-item loading. Further analysis of the correlation matrix (See Table 9) showed that PEOU was highly related to almost all other measures. This indicated that the PEOU measurement might be unstable. Therefore this entire measure was removed from the study. A third factor analysis was conducted.

This third and final run (see Table 6) revealed that the FIN measurement loaded strongly on its own component. This indicates that the User Competence construct contains two distinct latent variables; Computer Knowledge measured by BR and DEP, and Knowledge Application measured by FIN. The final run also reveled that the SE and PU measures each loaded on their own component. This indicates that the User Beliefs construct contains two distinct latent variables; User Confidence measured by SE and System Beliefs measured by PU. Because the original User Competence and User Beliefs constructs are divided into two latent variables, each hypothesis associated with these constructs became a multi-part hypothesis. Both parts must be found significant for the original hypothesis to be fully supported.

The final factor analysis revealed 40 items loading onto five independent components with eigenvalues greater than one, explaining over 70% of the variance (see Table 7). Eigenvalues that are greater then 1.0 usually account for more variance (Shannon, 2001). The remaining six measures; breadth (BR), depth (DEP), finesse (FIN), user satisfaction (SAT), self-efficacy (SE), and perceived usefulness (PU), loaded on to five latent variables; Computer Knowledge, Knowledge Application, User Confidence, System Beliefs, and User Satisfaction.

Reliability Testing

The next phase of the analysis was to check the reliability of the scales. Before examining the Cronbach's alpha for each of the measures, an attempt was made to logically split the measures. This was done in order to obtain multiple measures of each latent variable in the model as recommended by Jaccard and Wan (1996). Having multiple measures in the model enables the LISERL software to estimate the measurement error (Jöreskog and Sörbom, 2002). The SAT measure was divided into two measures; SAT1, user satisfaction about the information product provided by the computer system, and SAT2, user satisfaction about the computer system itself. The SE measure was also divided into two measures, SE1, self-efficacy with no human resources for assistance, and SE2, self-efficacy with human resources available for assistance. Table 8 shows that the Cronbach's alpha for each multi-item measure (with the exception of TR1 and TR2 as noted above) and all alphas are reported above the recommended .70 alpha needed to consider the scales reliable (Nunnelly, 1978).

Table 6: Factor Analysis Results

Item	Component: Computer Knowledge	User Satisfaction	System Beliefs	User Confidence	Knowledge Application
BR1B	0.6961				
BR2B	0.7770				
BR3B	0.6687				
BR4B	0.8282				
BR5B	0.7585				
DEP1B	0.7272				
DEP2B	0.8589				
DEP3B	0.8251				
DEP4B	0.7517				
DEP5B	0.8607				
DEP6B	0.8237				
SAT1		0.6317			
SAT2		0.7335			
SAT3		0.7645			
SAT4		0.6968			
SAT5		0.7887			
SAT6		0.7783			
SAT7		0.8359			
SAT8		0.8079			
SAT9		0.7986			
SAT10		0.6924			
SAT11		0.8256			
SAT12		0.8204			
PU1			0.7937		
PU2			0.8523		
PU3			0.8659		
PU4			0.8817		
PU5			0.8355		
PU6			0.8232		
SE3B				0.7433	
SE4B				0.8065	
SE5B				0.8594	
SE6B				0.7639	
SE7B				0.7035	
SE8B				0.7612	
FIN1					0.8078
FIN2					0.7778
FIN3	0.4456				0.7684
FIN4	0.4572				0.7585
FIN5	0.4381				0.7376

N = 415 values below .4 masked

Table 7: Eigenvalues and Variance Summary

Component	Eigenvalues	% of Variance	Cumulative %
1	8.02	20.05	20.05
2	7.65	19.13	39.18
3	4.85	12.13	51.31
4	4.33	10.83	62.14
5	3.55	8.88	71.02

N = 415

Descriptive Statistics

Table 8 provides a summary of descriptive statistics including the number of items in each measure the latent variable each measure is associated with. The mean, standard deviation, skewness, and kurtosis for each measured variable used in the study are reported. In addition, due to the variety of scales used in the study, scale range, minimum and maximum are reported. For the purposes of this study, all latent variables are considered along a continuous scale.

Table 8: Descriptive Statistics

Latent Variable MEASURE (items)	Range	Min	Max	Mean	Std. Dev.	Skewness	Kurtosis	α
Computer Experience								
EXP (1)	39	0.00	39.00	13.05	6.62	0.17	0.26	-
Computer Training								
TR1 (17)	69	0.00	69.00	8.89	8.76	2.34	9.84	-
TR2 (4)	100	0.00	100.00	10.99	10.92	2.93	14.13	-
Education Level								
EDU (1)	9	12.00	21.00	16.49	2.07	-0.58	0.32	-
System Beliefs								
PU (6)	4	1.50	5.00	4.47	0.62	-1.49	3.48	.9502
User Confidence								
SE1 (3)	10	0.00	10.00	6.67	2.01	-0.58	-0.20	.8141
SE2 (3)	10	1.00	10.00	7.29	1.99	-0.78	.192	.8794
System Use								
APPS (1)	4	1.00	5.00	3.77	1.04	-0.46	-0.53	-
TASK (1)	4	1.00	5.00	4.33	1.07	-1.47	1.07	-
TIME (1)	4	1.00	5.00	4.72	0.73	-2.83	7.71	-
FREQ (1)	2	3.00	5.00	4.99	0.16	-11.51	137.91	-
User Satisfaction								
SAT1 (7)	4	1.29	5.00	3.80	0.57	-0.58	1.71	.8897
SAT2 (5)	4	1.40	5.00	3.72	0.61	-0.59	1.29	.9055
Computer Knowledge								
DEP (6)	7	1.00	8.00	4.34	1.62	-0.49	-0.84	.9342
BR (5)	6	1.00	7.00	3.91	1.36	0.13	-0.48	.9018
Knowledge Application								
FIN (5)	6	1.00	7.00	4.13	1.50	-0.21	-0.79	.9423
N=415								

To evaluate data using SEM, normality must be assumed. Jaccard and Wan (1996) suggest that a moderate deviation from normality occurs when skewness is greater than 2 and kurtosis is greater than 7. The skewness and kurtosis measures from Table 8 indicate that the measures of Computer Training, TR1 and TR2 as well as measures of System Use TIME and FREQ violate these parameters. In addition, FREQ has close to zero standard deviation, indicating almost no variance. Without variance statistical analysis cannot be performed. Closer examination of the data reveals only 4 subjects used their computer less than "several times a day." The FREQ measurement is withdrawn from the study. The FREQ and TIME measurements were withdrawn from the study. The removal of these measurements is further discussed in Chapter V as an additional finding. Unfortunately there are no other measures for Computer Training other than TR1 and TR2, counts of training events. Because literature indicates training is a significant factor in evaluating a user's abilities with computers (Nelson and Cheney, 1987; Amoroso and Cheney, 1991), both TR1 and TR2 remain in the study. However the conclusions from this study must be observed with caution. The high level of positive kurtosis found in these measures may lead to an increased chance of Type I error (Jaccard aand Wan, 1996).

Correlation Matrix

The correlation matrix with a single-tail test of significance for all the observed measures in the model is presented in Table 9. As expected the correlations between measures of Computer Knowledge, BR and DEP, and Knowledge Application, FIN, are strong; as are the correlations between the measures of User Confidence, SE1 and SE2 and System Beliefs, PU.

Table 9: Correlation and Covariance Matrices

Measure	TR1	TR2	EXP	EDU	BR	DEP	FIN	PU	SE1	SE2	SAT1	SAT2	APPS	TASK
TR1	**76.8**	47.81	13.77	-1.88	2.09	2.36	3.31	.61	2.40	1.87	.24	.19	1.12	.26
TR2	.50*	**119.22**	21.77	-2.96	4.68	5.06	5.65	1.40	5.34	3.88	.68	.55	2.63	1.01
EXP	.24*	.30*	**43.76**	.61	.58	-.04	.89	-.15	.10	-.27	-.19	-.10	.73	.60
EDU	-.10*	-.13*	.04	**4.30**	.49	.62	-.04	-.15	-.25	-.25	-.20	-.19	.02	-.08
BR	.17*	.31*	.06	.18*	**1.86**	1.77	1.18	.18	1.45	1.31	.14	.09	.536	.25
DEP	.17*	.29*	0	.18*	.80*	**2.64**	1.39	.23	1.62	1.52	.20	.15	.65	.27
FIN	.25*	.35*	.09*	-.01	.58*	.57*	**2.24**	.37	1.57	1.32	.25	.22	.66	.45
PU	.11*	.21*	.08	-.12*	.21*	.23*	.40*	**.38**	.41	.39	.17	.15	.15	.12
SE1	.14*	.24*	.01	-.06	.53*	.50*	.52*	.33*	**4.06**	3.47	.41	.31	.59	.42
SE2	.11*	.18*	-.02	-.06	.48*	.47*	.44*	.32*	.87*	**3.97**	.34	.25	.62	.32
SAT1	.05	.10*	-.05	-.16*	.16*	.20*	.28*	.45*	.34*	.28*	**.34**	.30	.04	.03
SAT2	.04	.09*	-.03	-.16*	.12*	.17*	.26*	.42*	.27*	.22*	.86*	**.33**	.06	.04
APPS	.12*	.23*	.11*	.01	.38*	.38*	.43*	.24*	.28*	.30*	0.07	.10*	**1.08**	.49
TASK	.03*	.09*	.09*	-.04	.17*	.15*	.28*	.18*	.19*	.15*	0.05	0.07	.44*	**1.14**

N = 415 correlations below diagonal; variances bolded on diagonal; covariances above diagonal

* p < .05

The measure of Computer Experience, EXP, is only slightly correlated with one measure, FIN. Because the literature touts Computer Experience as significantly important to measures of User Beliefs and User Competence (Rivard and Huff, 1988; Tay and Ang, 1994; Ein-Dor and Segev, 1991; Igbaria and Nachman, 1990) EXP's lack of correlations with these measures was suspect. Since the unit of measure for EXP is "years," correlations with other measures indicated in "years" were observed. This revealed a significantly high correlation ($r = .6280$) between EXP and the Age demographic. This indicates that the Computer Experience variable is, in essence, a surrogate measure for Age and takes on similar characteristics of Age in the research model. Previous research has shown that computer related skills and knowledge as well as attitudes and beliefs are negatively related to Age (Igbaria and Nachman, 1990; Ein-Dor and Segev, 1991). Assuming Computer Experience is a surrogate for Age, a negative relationship with Computer Knowledge and User Confidence is expected. A two-tailed test of significance between EXP and the other measures in the study revealed a negative correlation with Computer Knowledge and User Confidence. It was determined that the measure for Computer Experience, EXP, was a poor indicator of computer related experience. In addition, the wording of the question on the survey did not specify what kind of computing experience. It is probable that many respondents included experience with mainframe and mini computers, whereas the focus of this study is on personal, desktop computing. Since the User Effectiveness Survey did not contain additional measures of computing experience, the Computer Experience variable was dropped from the study. The positive correlation between Computer Experience and Age is addressed in Chapter V as an additional finding. Based on the correlation matrix and

the hypotheses outlined in Chapter II, Figure 10 represents the revised research model to be tested.

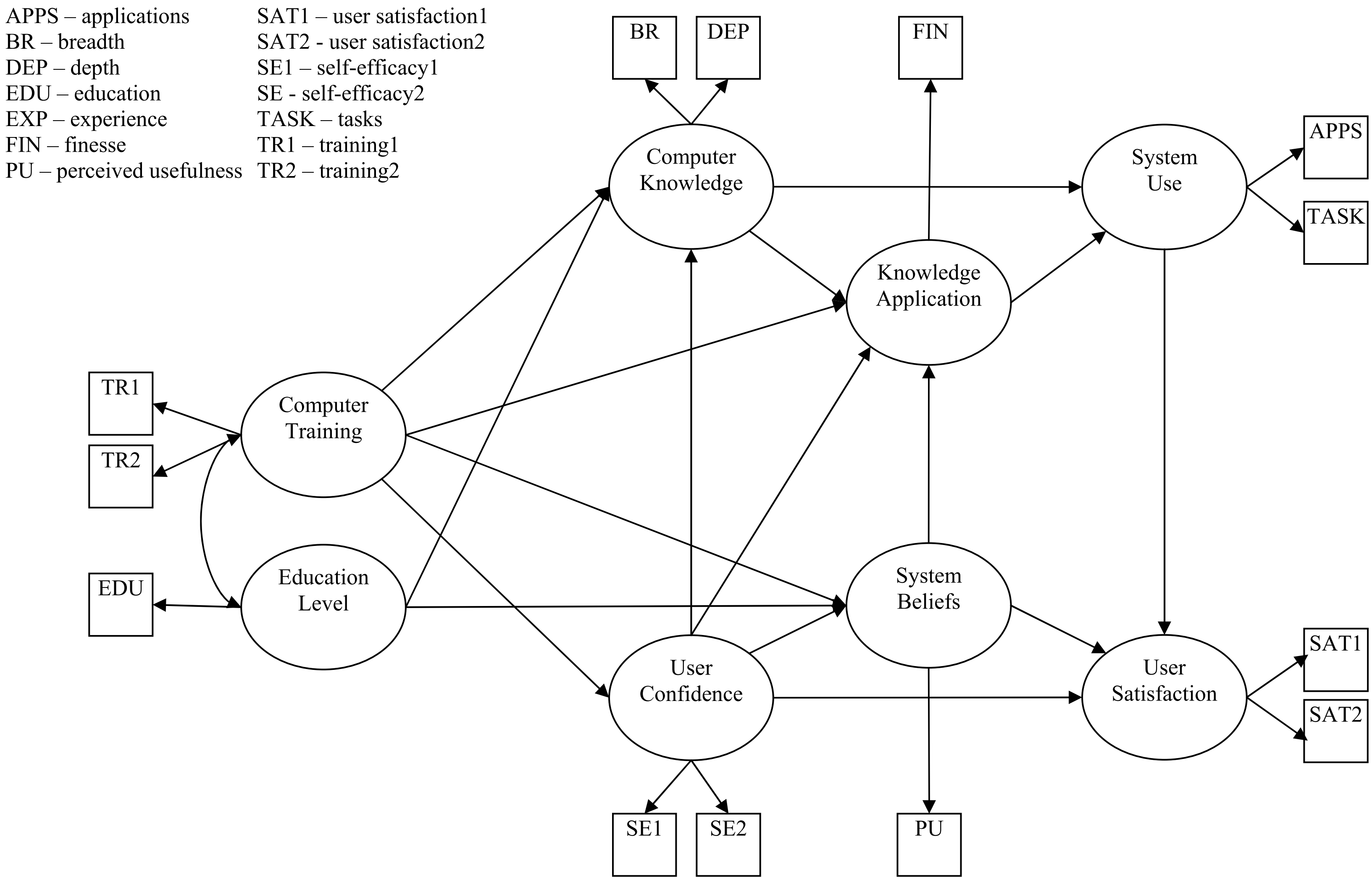

Figure 10: Revised Research Model

Structural Equation Modeling

As discussed in Chapter III, structural equation modeling (SEM) is used to test the twelve hypotheses associated with research questions one and two. The LISERL 8.52 software package is used to conduct the SEM analysis. LISERL uses the covariance matrix (see Table 9) of the measured variables as input. A series of eight matrices are programmed to provide information about hypothesized relationships between exogenous and endogenous variables and error measurements (Jöreskog and Sörbom, 2002). For this model, the exogenous variables are Computer Training, Computer Experience, and Education Level. Endogenous variables include User Confidence, System Beliefs, Computer Knowledge, Knowledge Application, User Satisfaction, and System Use. While all eight matrices are needed to obtain results from SEM, the following will provide a bulk of the results needed to answer the research questions and hypotheses:

1. The beta matrix provides information on the relationships between endogenous variables.
2. The gamma matrix demonstrates the relationships between exogenous variables and endogenous variables.
3. The psi matrix provides the amount of residual error in the endogenous variables.

The psi matrix is the source for E scores (residual error). The E score is the total unexplained variance in the latent construct. By calculating 1 - E, a value synonymous with R-squared values (explained variance) found in regression analysis is obtained. The E score is the value used to compare the baseline model with the research model.

The first step in conducting SEM analysis is to verify the revised research model is a good fit as verified by model fit indices. Measures of absolute fit include chi-

squared ($\chi 2$), its p-value, the standardized root mean square residual (Std. RMR), and the goodness-of-fit index (GFI). These measures look at fit by comparing predicted verses observed variances and covariances. Measures of parsimonious fit include the root mean square error of approximation (RMSEA) and the p-value estimating the closeness of fit. These measures consider the maximum likelihood of fit as a function of the degrees of freedom (df), and penalize liberal use of estimating parameters. A measure of relative fit is the comparative-fit-index (CFI). This measure considers the relative fit of the model to the null model (no significant relationships) rather than the perfect model (all significant relationships). Table 10 shows six indices of model fit and the values which indicate good fit (Jaccard and Wan, 1996).

When the revised research model was run with the data from the survey, a relatively poor fit model was found. The chi-square statistic was 80.45 with 80 df at $p = .022$, lower than the recommended .05 needed for good fit and therefore the revised model, as proposed, was rejected. To find a better fit model, insignificant and additional relationships were examined. Observation of the gamma and beta matrix revealed several non-significant relationships. The modification indices also recommended additional relationships not identified in the correlation matrix. In an effort to produce a better fit model, the insignificant relationships were removed and the recommended additional relationships were added. The next run resulted in a good fit model (see Table 10 and Figure 11). In order to get a good fit model, all non-significant relationships were removed from the model.

Table 10: Research Model Good Fit Indications

	Good Fit Indicator	Constraint	Research Model
	df		52
	$\chi 2$		63.37
1.	$p(\chi 2)$	> .05	0.13
2.	Std RMR	< .05	0.026
3.	GFI	> .90	0.98
4.	RMSEA	< .08	0.023
5.	p(RMSEA)	> .05	1.00
6.	CFI	> .90	1.00

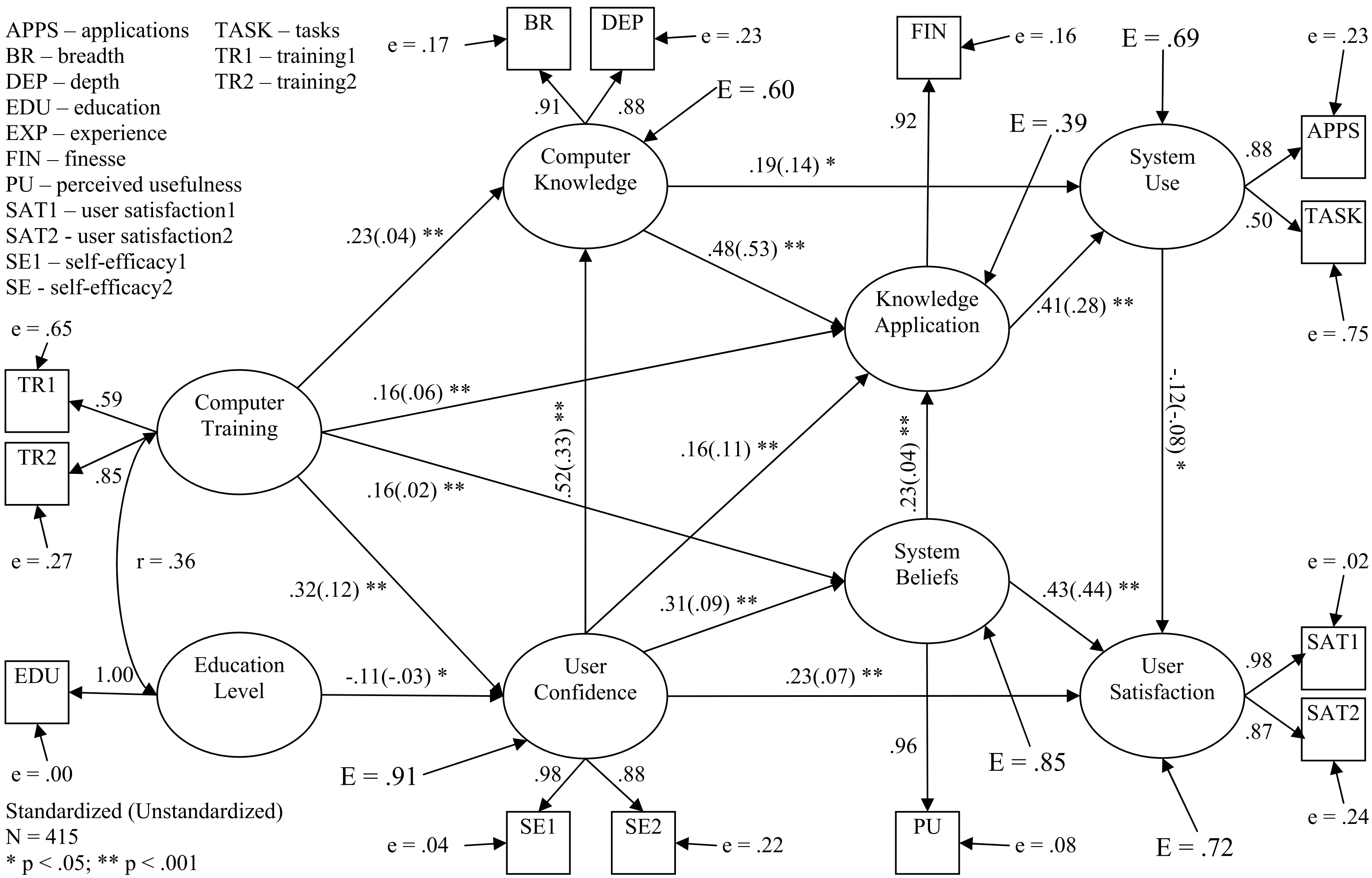

Figure 11: Final Research Model

Hypotheses Testing

To report the findings for the twelve hypotheses associated with research questions one and two and the additional relationships in the model, the significance level of the unstandardized path coefficients between latent variables is evaluated. Tables 11 to 13 show the direct and indirect standardized path coefficients and their significance based on the unstandarized path coefficients. To achieve the best-fit model, all non-significant relationships were removed.

As mentioned earlier, the original User Competence and User Beliefs constructs were divided into two latent variables; therefore each hypothesis associated with these constructs became a multi-part hypothesis. All the new parts of the original hypothesis need to be found significant for the hypothesis to be supported. Support for a hypothesis implies the null (no path) was rejected.

Table 11: Hypotheses associated with Research Question One

#	Hypotheses associated with Research Question One	Direct Effect	Indirect Effect	Supported
H1	Education Level will positively impact User Confidence	-.11*	-	No
	Education Level will positively impact System Beliefs	-	-.03*	
H2	Education Level will positively impact Computer Knowledge	-	-.06*	No
	Education Level will positively impact Knowledge Application	-	-.06*	
H3	Computer Training will positively impact User Confidence	.32**	-	Yes
	Computer Training will positively impact System Beliefs	.16**	.10**	
H4	Computer Training will positively impact Computer Knowledge	.23**	.17**	Yes
	Computer Training will positively impact Knowledge Application	.16**	.31**	
H5	Computer Experience will positively impact User Confidence	-	-	Invalid
	Computer Experience will positively impact System Beliefs	-	-	
H6	Computer Experience will positively impact Computer Knowledge	-	-	Invalid
	Computer Experience will positively impact Knowledge Application	-	-	
H7	User Confidence will positively impact Computer Knowledge	.52**	-	Partially
	User Confidence will positively impact Knowledge Application	.16**	.33**	
	System Beliefs will positively impact Computer Knowledge	-	-	
	System Beliefs will positively impact Knowledge Application	.24**	-	

N = 415
** p < .001; * p < .05

Table 12: Hypotheses associated with Research Question Two

#	Hypotheses associated with Research Question Two	Direct Effect	Indirect Effect	Supported
H8	Computer Knowledge will positively impact System Use	.19*	.20*	Yes
	Knowledge Application will positively impact System Use	.41**	-	
H9	Computer Knowledge will positively impact User Satisfaction	-	-.04*	No
	Knowledge Application will positively impact User Satisfaction	-	-	

N = 415
** p < .001; * p < .05

Table 13: Hypotheses associated with other Relationships

#	Hypotheses associated with Additional Relationships in the Model	Direct Effect	Indirect Effect	Supported
H10	User Confidence will positively impact System Use	-	.30**	Partially
	System Beliefs will positively impact System Use	-	.10**	
H11	User Confidence will positively impact User Satisfaction	.23**	.10**	Yes
	System Beliefs will positively impact User Satisfaction	.43**	-	
H12	System Use will positively impact User Satisfaction	-.12*	-	No

N = 415
** p < .001; * p < .05

To test the hypotheses associated with research question three, the chi-squared test for independence was used to evaluate scores obtained from the survey for factors involving EUC success and User Competence. To evaluate EUC success, participants were categorized according to their scores for System Use (mean score of TASK and APPS) and User Satisfaction (mean score of all SAT items) (See Table 14).

Table 14: End User Computing Success Levels

User Satisfaction	System Use			
	Low (< 4.00)		High (>= 4.00)	
	#	%	#	%
Low (< 3.75)	55	13.3	110	26.5
High (>= 3.75)	67	16.1	183	44.1

About 44% of the participants engage in successful EUC as defined by high User Satisfaction and high System Use. Over 13% were dissatisfied with computers; completing few job-related tasks using few computer applications. About 16% were satisfied with computers, but failed fully utilize them indicating that computing resources may be under utilized. Finally, over 26% indicated they were unsatisfied with computers but still used them at a high rate. This situation may indicate that computing resources are being used inefficiently.

To evaluate User Competence, participants were categorized according to their scores for Computer Knowledge (mean score of BR and DEP items) and (score of FIN items) (See Table 15).

Table 15: User Competence Levels

Computer Knowledge	Knowledge Application			
	Low (< 4.00)		High (>= 4.00)	
	#	%	#	%
Low (< 4.09)	128	30.8	72	17.3
High (>= 4.09)	49	11.8	166	40.0

Table 15 shows that over 40% of the participants fall within the high range of all three categories of competence. At the same time, almost one-third of the participants fall within the low range of both Computer Knowledge and Knowledge Application.

Table 16 shows the results of the chi-square tests for EUC success and User Competence.

Table 16: Chi-Squared Test results for EUC Success and User Competence

User Satisfaction	P(S)	P(S|U)	P(S|U')	X^2
Satisfied User	0.71	0.62	0.56	2.04
N = 415	P(S) probability of High System Use. P(S|U) and P(S|U') probability of high System Use given a satisfied or unsatisfied user.			

Computer Knowledge	P(K)	P(K|C)	P(K|C')	X^2
Knowledgeable User	0.57	0.70	0.60	71.93*
N = 415. * p < .001	P(K) probability of high Knowledge Application. P(K|C) and P(K|C') probability of high Knowledge Application given high or low Knowledge level.			

The conditional probability of witnessing high system use given a user is satisfied with the system and information product does not support *H13*. The conditional probability of finding a user with the ability to apply computer knowledge, given the user is knowledgeable supports *H14*.

Participant Comments

In the last section of the User Effectiveness survey, the study's participants were given a chance to voice some thoughts about the computing environment in the Air Force (See Appendix C). Of the 415 usable responses, 54 participants provided comments about the computing environment. In Table 17 these comments are categorized and summarized.

Table 17: Summary of Participant Comments

Category	Frequency*	%
Additional quality training; software upgrades w/o training	15	24.2%
Computers are tools; should be used for everything	9	14.5%
Email/information/tasking overload	8	12.9%
Don't need/want additional capabilities; software is user-friendly; no training required	6	9.7%
Comfortable with computers; self taught/motivated to learn	6	9.7%
Problems w/ network	5	8.1%
Lack time/incentive/requirement to attend formal computer training	5	8.1%
Information not always accurate/timely	5	8.1%
Exposure/Experience with other hardware/software aids learning	3	4.8%
*Total Comments (some participants provided more than one comment)	62	100%

The participant comments ranged from those who believed additional, formal computer training was needed (24.2%) to those who believed self-taught methods of computerized training to be more valuable (9.7%). Some (9.7%) felt they had achieved a high level of proficiency with the hardware and software they needed to know to complete job tasks and did not need further training in additional computing capabilities. The participants also pointed out inhibitors to seeking out additional computer training such as lack of time or motivation (8.1%). Finally, a group pointed out that, with the proliferation of computing technology, it is easy to communicate globally, however they are inundated with irrelevant emails (12.9%) and inaccurate information (8.1%). As put by one participant, "Email is good and bad. [I] can spend entire day responding to e-mail without getting primary tasks done. Information is often hastily put together and sometimes inaccurate."

Summary

To summarize, using SEM techniques, a good fit model ($\chi 2$ = 63.37 w/52 df; p = .13) was found to test hypotheses associated with research questions one and two along with relationships found in the model not associated with a research question. Additionally, the testing of hypotheses associated with research question three was conducted using the chi-squared test for independence. Of the fourteen hypotheses tested, five were supported, five were not supported, two were partially supported, and two were invalid. Participant comments were included to provide a subjective look at the computing environment in the Air Force organization.

V. Discussion

Introduction

Considering the enormous potential of computer systems to aid the Air Force in combat, combat support, and business operations, and the huge investment the Air Force is making in EUC technology, it is crucial to optimize its use. Evaluating those factors leading to computing competence and the outcomes of computing competence is a step in the right direction.

To answer the research questions below, data from 415 survey responses were analyzed.

1. Are User Characteristics and Beliefs antecedents to User Competence?
2. Are EUC success factors outcomes of User Competence?
3. Is the AF positioned for current and future EUC success?

The following sections contain discussion about the findings and a review of the data analysis. These discussions are followed by implications of this research for practical and theoretical applications. The sections following this note research limitations and recommendations for future research. The final section of this chapter provides an overview of this research effort.

Research Question One

Based on the results from hypothesis one through seven used to answer research question one, it was determined that Computer Training, User Confidence, and System Beliefs all had significant impacts on Computer Knowledge and/or Knowledge Application. Together, these variables account for 40% and 61% of the variance in Computer Knowledge and Knowledge Application respectively (see Table 17).

Table 18: Variance Explained by Research Model

Variable	Research Model
Computer Knowledge	40%
Knowledge Application	61%
System Use	31%
User Satisfaction	28%

Interestingly, education levels did not play a role in additional computer related knowledge or additional ability to apply the knowledge gained. This may be a result of the environment in which higher education levels are gained. EUC resources in colleges and universities are used on a regular basis. Email, Internet research, word processing, and spreadsheet development are conducted on a routine basis. Since these tasks are routine, computer users become skilled and knowledgeable only about those hardware and software platforms needed to complete assignments. At some point, no new skills or knowledge is needed to complete routine assignments. This type of environment

stagnates learning and does not lend itself to end users seeking out new ways to apply computer related skills and knowledge.

Results confirm what previous literature has said about training. As the number of computer related training events increase, computer knowledge and the ability to apply computer related knowledge also increases. As well, an increase in the number of computer related training events a person attends results in an increase in confidence operating computer systems and an increase in the perception that computer systems are useful in completing job-related tasks.

Unfortunately, Computer Experience could not be evaluated as it was dropped from the study.

Results from hypothesis seven indicate that believing in one's abilities to operate computer systems and that the computer system is useful in completing job tasks will result in an increased ability to apply computer-related knowledge to creatively solve problems. Only beliefs about one's abilities to operate a computer may lead to increased computer related knowledge. This finding might be interpreted as user beliefs acting as motivators to apply computing knowledge and in some instances seek additional knowledge; self-teaching.

Knowledge, skills and the ability to apply knowledge and skill are required in two situations (Clark and Estes, 2002). In the first instance, whenever personnel are unsure of how to accomplish job tasks. When this occurs, providing additional information on how to accomplish the task or additional training may help alleviate the situation. The second situation occurs when future challenges require creative problem solving, people call upon previously acquired knowledge, skills and use the ability to apply each in solving

problems. To prepare for these future challenges, education provides the "conceptual, theoretical, and strategic" knowledge and skills to handle future problems (Clark and Estes, 2002: 59).

Research question one verifies that computer training and education are antecedents to the acquisition of knowledge, skills, and the ability to apply each in performing job related tasks using computer systems. Users at the Aeronautical Systems Center (ASC) unsatisfied with computers or the information product they produce, might benefit from additional information about how to accomplish computer related job tasks and/or computer training. In order to prepare ASC personnel for future technology acquisitions, such as software and hardware upgrades or the purchase of an entirely new information system, training seems to be the key to future ability in applying knowledge and skills. This study investigated the overall education level obtained at traditional colleges and universities. Additional knowledge may also be obtained through education about the organization, its mission, strategic goals and the processes implemented to achieve such goals. Such knowledge may aid personnel in applying their computer related knowledge and skills to solving problems standing in the way of mission accomplishment or strategic objectives. Without that knowledge, personnel would not understand or recognize situations in which their computer related skills and knowledge might be applied to solve a problem.

Research Question Two

System Use and User Satisfaction are the factors used to evaluate EUC success. The research model explains 31% and 28% of the variance in System Use and User

Satisfaction, respectively (see Table 17). However, Computer Knowledge and Knowledge Application only impacted one factor constituting EUC success, System Use. The significant path coefficients of .18 for Computer Knowledge → System Use and .42 for Knowledge Application → System Use suggest that these latent variables of User Competence have significant value in determining a portion of EUC success and should be considered in future research.

The context of computer system use in this study is that a certain amount of computer use is mandatory. System use above this mandated level of use may be explained by the amount of computer knowledge one has and the ability to apply that knowledge to solve job-related tasks. Therefore, additional competence will lead to additional utilization of computing resources and capabilities.

An individual's level of computer knowledge and ability to apply that knowledge does not impact how satisfied that person is about the computer system or the information product it produces, directly or indirectly. It may be that there is an additional mediating variable not included in the study. The computer experience variable was dropped from the study. It is possible that the knowledge and abilities gained from computer experience may have a significant impact on the satisfaction of the user.

Research question two shows that EUC computing success is influenced by computer competence and beliefs about systems. An increase in computer competence may overcome perceptions about the uselessness of a computer system. This information can be used when evaluating new technology purchases. It is possible that increasing computing competence in personnel may produce the same desired result as purchasing new technology. The increase in computing competence may allow users to tap in to

computing capabilities unknown or unable to use because of a lack of knowledge about the system. Tapping in to these unused computing resources may save ASC from purchasing computing capabilities that are redundant.

Research Question Three

Evidence presented from the results of the chi-squared tests is mixed. The result from hypothesis thirteen indicates a relatively equal distribution of end users practicing successful computing and those who either avoid using computing resources or use them inefficiently. Interpreting this finding alone would indicate the AF is in a computing crisis because there is not a greater proportion of users practicing successful EUC. At the same time, the findings from hypothesis fourteen indicates that a greater proportion of end users have a high level of user competence. So, while the AF organization does not seem to be successful at EUC computing, individual members seem to have a high level of computer competence. This seems to indicate there is a variable missing. What is it that prevents AF personnel from engaging in successful computing when they seem to have the competence level necessary to do so? It may be a combination of factors, false information in the computer systems, poor support from IT departments and/or cultural mindsets preventing users from exploring the additional capabilities computers have to offer. Until further research is completed, the question as to whether or not the AF organization is successfully using EUC resources cannot be answered.

Additional Findings

While not specifically addressing a research question, the additional relationships found in the model can provide insight to EUC in the AF organization. Results indicate

that beliefs about one's ability to operate a computer system and the usefulness of that system do not alone impact system use (see Table 13). Rather, the relationship between user beliefs and system use seems to be mediated by one's computer knowledge and ability to apply that knowledge. This is consistent with findings by Compeau and Higgins (1995a) suggesting that beliefs about outcomes of behavior or the ability to engage in the behavior are not sufficient to explain behavior. In this case, beliefs must be mediated by user competence in order to impact the behavior, system use.

Results from hypothesis eleven indicate that the more a person believes he or she can successfully operate a computer system and believes it to be useful in completing job-related-tasks; the more satisfied the person will be about the system and its information product. This was expected because of high correlation between beliefs and attitudes found throughout literature.

Results from hypothesis twelve indicate that additional computer use results in lower levels of satisfaction in the system itself and the information product it produces. It may be that it is additional mandatory use of computer systems that leads to dissatisfaction, especially when knowledge and ability to apply the knowledge are not present.

Measures of system use used less than 5 years ago are no longer valid. The measures of system use were used in studies as recently as 1999 (Al-Gahtani and King, 1999). The scale for the frequency of system use ranged from 1 = "less than once a month" to 5 = "at least once per day" may be adequate for studies in which the focus is one software or hardware platform. In this study, the focus was on overall computing, including all activities done using a computer system. The range of the frequency of

system use measure was narrowed, from 1 = "less than once a week" to 5 = "several times per day" to account for the mandatory computer use environment. This did not work; of the 415 participants completing the survey, only four indicated they used a computer at work less than "several times per day." With the advent of new network management tools, system administrators are able to easily capture several dimensions of actual system use. Using this method to capture system use may bring further validity to EUC research.

It was interesting to see that participants of the study perceived computers to be easy to use, but as indicated by item 5 of the Perceived Ease of Use (PEOU) scale, the participants also perceive becoming skillful using computers as difficult. This perception, that it is difficult to obtain skills needed to easily operate computer systems, may inhibit a person's motivation to learn more about computers and ways in which to use them in order to efficiently accomplish job tasks.

The high positive correlation between Age and Computer Experience was an interesting finding. Past studies indicated a negative correlation between Age and Computer Experience. Older generations did not grow up with the abundance of computer technology found in society today, therefore experience levels were expected to be low. The finding of a positive correlation between Age and Computer Experience indicates that the current generation of AF personnel has "grown-up" using computer systems.

Implications

For the Air Force, this study accomplished several tasks. First, it showed a positive relationship between user competence factors and EUC success factors. Without computing competence at the individual level, organizational computing may not be as successful, which, in-turn, may impact mission accomplishment. Second, it validated the importance of computer-related training in the development of computing competence in Air Force members. This is important considering survey participants averaged less than one computer training event per year. This study may provide incentive to increase training to take advantage of computing resources now lying dormant. Finally, this study provides evidence that increasing the level of computing competence may lead to successful computing in the organization. Therefore, an alternative to purchasing new computing technology may be to increase users' competence level through training programs. Depending on the situation, this may be significantly cheaper and bring about a higher return on the investment in the long run.

In the realm of academia, this research provided additional material to use for future research efforts. First, an integrated conceptual model was developed, based on validated models of cognitive learning (Compeau et. al., 1999; Compeau and Higgins, 1995a; 1995b) technology acceptance (Davis, 1989), and system success (Delone and McLean, 1992; 2002). The user competence construct, originally proposed as a three-dimensional construct (Malcon et. al., 1997) was seen in this study as only having two independent dimensions. Finally, it is hoped that the findings of this research effort will, in some way, add to the body of knowledge known as End User Computing.

Limitations

Measures were a limiting factor in this study. First, self-reported computer training suffered from moderate positive skewness and kurtosis. Self-reported indicates that the reliability of the measure rests with the memory of the participant. The difficulty with moderate levels of positive kurtosis is that it may cause type I errors (West, Finch, and Curran, 1995). Type I errors occur when the alternate hypothesis is accepted (significant relationship exists) when in fact the null hypothesis (no significant relationship exists) should have been accepted. In the study, all relationships associated with computer training were accepted. Second, using years of computer related experience resulted in computer experience being dropped from the study, even though much of the previous research on computer experience emphasized its importance in the study of information systems and EUC. Finally, the system use measures were ordinal in nature, but assumed continuous for the purposes of this study. The items used to evaluate the self-reported measures of system use were close-ended, leading to high levels of skewness and kurtosis. This lead two of the system use measures dropping from the study. The last two measures were ordinal in nature, however, to complete the evaluation, they were assumed to be continuous data. Because many of the measures had questionable characteristics, the results of this study should be viewed with caution.

Another important limitation can be found in the population selected for this study. While the population of interest is the entire AF civilian and military population, the Aeronautical Systems Center is not a typical AF organization. The population consists of over 60% civilians whereas the AF overall population consists of 30% civilian. In addition, there is low representation in the study of enlisted personnel, less

than 5%. For these reasons, care should be taken when attempting to generalize the results of this study to the entire AF population.

Future Research

Numerous opportunities exist for future research in the realm of user competence. To begin, this study did not touch on skill-based computer competence. Marclon, et. al., (2000) recommended skill based experiments as yet another method of analyzing users' competence. In addition, one of the difficulties with this study was attempting to measure beliefs and attitudes before and after a specific behavior. Using both experimental and questionnaire methodologies would enable future researchers to examine attitudes and beliefs about computer systems as well as the development of skills over a period of time.

Second, the only external variables this study evaluated were individual characteristics. Future researchers may want to take on the challenge of evaluating other external variables such as task and organizational characteristics and their value as antecedents to user competence.

Finally, this study integrated factors of the ISSM into an integrated model to evaluate the User Competence construct. Now that the User Competence construct is found to be significant in determining EUC, the next logical step would be to incorporate the User Competence construct into the full ISSM (DeLone and McLean, 2002) model.

Conclusion

The results of this study support the belief that certain factors such as training, self-efficacy, and perceptions about computers systems lead to a certain amount of

competence when operating computer systems. Education levels seemed to inhibit the development of computing competence.

This study revealed the importance of both user competence and user beliefs on successful EUC. User competence is a strong indication of additional computer system use, while beliefs about the usefulness of a computer system and one's ability to operate it have a direct impact on the satisfaction level of the user and an indirect impact on the amount a system is used.

The results of this study are inconclusive as to whether or not the AF organization is successfully using the full capabilities of its computer systems. A majority of personnel seem to have the competence needed to exploit current computing capabilities, it just doesn't seem to be happening.

In summary, this study used an integrative approach to explain EUC success in the AF organization. Combining aspects of previously validated models and incorporating an additional construct, antecedents and outcomes of user competence were discovered and further evaluated. While this study has limitations, it attempted to discover the role computing competence plays when users must interact with computer systems to obtain information needed for successful decision-making. Computing technology is ever changing and growing; users of that technology must change and grow with the technology to take full advantage of its capabilities. As one study participant put it, "Everyone needs to increase their ability to leverage information technology, it never stands still, so no one can stay an expert without significant investment."

Appendix A: The User Effectiveness Survey

INFORMATION ABOUT THIS RESEARCH STUDY

Thank you for agreeing to participate in this research project. Your participation in this anonymous survey is strictly VOLUNTARY. Your knowledge and beliefs about computers will make an important contribution to the goals of this research project.

Description of the study: In order to assist Air Force organizations in helping people develop computer skills, we need to determine how familiar various people are with information technology. The Air Force can then use this information to design appropriate training and support systems which will provide the most benefit to the individuals and the Air Force.

How your responses will be used: The information you provide will help explain attitudes and abilities relating to effective use of computers. It will help the Air Force understand how personnel use computers in contributing to the mission, and better understand the cost/benefits of improving the competence of computer users. This research will not affect anyone presently in your organization in any way.

Anonymity of your responses: All of the information you provide will be anonymous. No identifying information is gathered in this study. You are welcome to discuss this questionnaire with anyone you choose. The data will be held for the duration of this study, which is planned for 6 months, with complete anonymity maintained throughout. Though your participation is completely voluntary, I would appreciate you completing the on-line questionnaire. This information is being collected for research purposes only and has been reviewed and approved by the Aeronautical Systems Center and Air Force Government Employees' Union.

Sponsors: The Office of the Air Force Chief Information Officer (AF-CIO) and the Aeronautical Systems Center, Human Resources (ASC/HR) sponsor this research.

PRIVACY ACY STATEMENT

In accordance with AFR 12-35, Paragraph 8, the following information is provided as required by the Privacy Act of 1974.

Authority: 10 U.S.C. 8012, Secretary of the Air Force; powers and duties; delegation by; implemented by AFI 36-2601, Air Force Personnel Survey Program.

Purpose: To obtain information regarding the influence of different factors influencing the competence of Air Force personnel that use computers.

Routine Use: To increase understanding of personnel capabilities in the use of computers. Data will be grouped prior to analysis. No analysis of individual responses will be conducted and only members of the research team will be permitted access to the raw data. Reports summarizing trends in large groups of people may be published.

Participation: Participation is VOLUNTARY. No adverse action will be taken against any member who does not participate in this survey or who does not complete any part of the survey.

Instructions

Your input is important. I need to know how many software packages you are able to use and how many technology concepts you understand. There are no "right" or "wrong" answers to any of the questions. Please tell me what you think.

Your first impressions are the ones of most interest to me; so do not spend an excessive amount of time on any one question. In some cases you may have forgotten some of what you once knew about an item. Please respond based on your **current** knowledge of that item.

A few questions ask you to assess your general impression of complex issues. If you find it difficult to determine your exact answer, please give your **best estimate**.

Please answer all questions. If you have never studied or used the technology, indicate by selecting "no knowledge." The survey should take 15-20 minutes to complete.

*Throughout the questionnaire you will be asked to indicate **courses** you have taken and topics you have **thoroughly self-studied (self-taught).***

*By **courses** I mean any formal class you attended of whatever length that had an instructor giving a lecture or demonstration.*

*By **thoroughly self-studied/self-taught** I mean any times you have studied the user manual or read books/magazine articles to learn about a package or topic **beyond** the requirements needed to solve some specific problem you faced. The purpose of this study should have been to gain a broad, general understanding of commands and features of the package.*

*Throughout the questionnaire you will be asked to indicate your **knowledge** of software, hardware, and computing concepts and policies. In the case of software, I am looking for you knowledge with regard to the **capabilities** of the software.*

When I refer to breadth and depth of knowledge (capabilities), keep in mind some people will know a lot about a few things (narrow breadth, deep knowledge), others may know a bit about a lot of things (wide breadth, shallow knowledge), others may know a little about few things (narrow breadth, shallow depth), and finally, some might know a great deal about many things (wide breadth, deep depth).

When I refer to a computer system, it includes the computer you use most often, software and hardware you can access and all information contained on the local and network drives.

This data collection instrument was adapted from a study conducted by Sid Huff of the Western Business School in London, Ontario, Malcolm Munro and Barbara Marcolin, both of the University of Calgary in Calgary, Alberta.

Section A

This section asks about your knowledge of software applications and computer hardware/peripherals. You will be asked to estimate how much you know about a wide variety of software and hardware.

Have you used...	State Number Courses Taken? (Thoroughly Studied = 1 course) ↓	How Many types Have a Working Knowledge of? ↓	How thorough Is Your Knowledge of the package you use most often? 0 = no knowledge 7 = complete knowledge
A-1. SPREADSHEETS (e.g., Lotus, Quattro Pro, Excel)	_____	_____	0 1 2 3 4 5 6 7
A-2 . DATABASES (e.g., dBase, RBase, Oracle)	_____	_____	0 1 2 3 4 5 6 7
A-3. WORD PROCESSING *(e.g., Word Perfect, MS Word)*	_____	_____	0 1 2 3 4 5 6 7
A-4. DESKTOP PUBLISHING *(e.g., Pagemaker, Ventura)*	_____	_____	0 1 2 3 4 5 6 7
A-5. ELECTRONIC MAIL (e.g. Outlook, Lotus Notes)	_____	_____	0 1 2 3 4 5 6 7
A-6. PERSONAL INFORMATION MANAGERS *(e.g., Packages that do scheduling, calendaring, and "to do" lists)*	_____	_____	0 1 2 3 4 5 6 7
A-7. REPORT GENERATORS/ QUERY LANGUAGES *(e.g., SQL, ADRS II, QBE)*	_____	_____	0 1 2 3 4 5 6 7
A-8. PERSONAL COMPUTER OPERATING SYSTEM *(e.g., DOS, OS/2, Windows, PC-Unix, MacIntosh)*	_____	_____	0 1 2 3 4 5 6 7
A-9. PROGRAMMING LANGUAGES	_____	_____	0 1 2 3 4 5 6 7

(e.g., Basic, Pascal, C, Fortran, Cobol, Assembly Language, Focus, Mapper, Ramis, Nomad)

A-10. MULTI-MEDIA EDITING _____ _____ 0 1 2 3 4 5 6 7
(e.g. Audio, Photo, Video, and Graphical editing packages)

A-11. JOB SPECIFIC SOFTWARE _____ _____ 0 1 2 3 4 5 6 7
(e.g., Software applications unique to your career field.)

A-12. ORGANIZATION SPECIFIC SOFTWARE _____ _____ 0 1 2 3 4 5 6 7
(e.g., Software applications unique to your organization/unit.)

A-13. WEB PAGE DESIGN _____ _____ 0 1 2 3 4 5 6 7
(e.g. Frontpage)

A-14. INTERNET BROWSER _____ _____ 0 1 2 3 4 5 6 7
(w.g. Explorer, Netscape)

A-15. PERSONAL COMPUTING HARDWARE _____ _____ 0 1 2 3 4 5 6 7
(e.g., IBM, Apple, MacIntosh, Sun Workstations, Compatibles)

A-16. REMOTE CONNECTIVITY _____ _____ 0 1 2 3 4 5 6 7
(e.g., connecting computers by way of Datapac, Telenet, or VPN)

A-17. HARDWARE PERIPHIALS _____ _____ 0 1 2 3 4 5 6 7
(e.g., printers, scanners, CD-RW Drives, ZIPDrives, modems, etc.)

Section B

This part of the questionnaire asks about your ability to use an unfamiliar piece of software. Often in our jobs we are told about software packages that are available to make work easier. For the following questions, imagine that you were given a new software package for your work. It doesn't matter specifically what this software package does, only that it is intended to make your job easier and you have never used it before.

The following questions ask whether you could use an unfamiliar software package under a variety of conditions. For each condition, please indicate whether you think you would be able to complete the job using the software package. Then, for each condition that you answered "yes", rate your confidence level for completing the job successfully by circling a number from 1 to 10, where 1 indicates "Not at all confident" and 10 indicates "Totally confident".

I COULD COMPLETE THE JOB USING THE SOFTWARE PACKAGE...

		NOT AT ALL CONFIDENT					TOTALLY CONFIDENT
B-1....if there was no one around to tell me what to do as I go.	YES..... NO	...1	2	3 …	…8	9	10
B-2....if I had only the software manuals for reference.	YES..... NO	...1	2	3 …	…8	9	10
B-3....if I had seen someone else using it before trying it myself.	YES..... NO	...1	2	3 …	…8	9	10
B-4....if I could call someone for help if I got stuck.	YES..... NO	...1	2	3 …	…8	9	10
B-5....if someone else had helped me get started.	YES..... NO	...1	2	3 …	…8	9	10
B-6....if I had a lot of time to complete the job for which the software was provided.	YES..... NO	...1	2	3 …	…8	9	10
B-7....if I had just the built-in help facility for assistance.	YES..... NO	...1	2	3 …	…8	9	10
B-8....if someone showed me how to do it first.	YES..... NO	...1	2	3 …	…8	9	10

Section C

In this section, we are interested in learning about the ***breadth*** of your knowledge of end user software, hardware, concepts, etc. For this, please concentrate on the ***variety*** of different things of which you have at least a minimum working knowledge. We are ***not*** interested here in the ***depth*** of your knowledge in any of the areas, solely in your ***breadth*** of knowledge. **Some people will know a lot about a few things (narrow breadth, deep knowledge), while others may know a bit about a lot of things (wide breadth, shallow knowledge).**

C-1. Consider all possible major **software applications.** As compared to an average end user in your organization, how would you characterize your ***breadth*** of knowledge of software application categories? (Circle number)................................1 2 3 4 5 6 7

Much Narrower — Much Broader

Of all major software application categories, estimate the percentage of which you have a basic working knowledge (Circle number).

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

C-2. Consider all possible **computer hardware.** As compared to an average end user in your organization, how would you characterize your ***breadth*** of knowledge of hardware platforms? (Circle number)..........................…………1 2 3 4 5 6 7

Much Narrower — Much Broader

Of all major computer hardware platforms, estimate the percentage of which you have a basic working knowledge (Circle number).

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

C-3. Consider all **programming languages**. This includes languages such as COBOL, BASIC, Fortran, Focus or SQL. It also includes "macro" languages which may be part of a software application package, such as the LOTUS 1-2-3 macro language, or the macro language built into the MS Word word processing package. As compared to an average end user in your organization, how would you characterize your ***breadth*** of knowledge of programming languages? 1 2 3 4 5 6 7

Much Narrower — Much Broader

Of all computer programming languages, estimate the percentage of which you have a basic working knowledge (Circle number).

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

C-4. Consider all major **information technology concepts and principles**. Examples would be: how a computer works; how a hard disk drive works; how to design a computer data base; how to go about fixing a program which has an error in it; telecommunications concepts; the basic role of a computer's operating system; etc. As compared to an average end user in your organization, how would you characterize your ***breadth*** of knowledge of basic computer concepts and principles?
(Circle Number) 1 2 3 4 5 6 7

Much Narrower — Much Broader

Of all basic computer concepts and principles, estimate the percentage of which you have a basic working knowledge (Circle number).

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

C-5. Overall, as compared to other people in your organization, how would you characterize your ***breadth*** of knowledge of end user computing?
(Circle Number)…………………………......................................1 2 3 4 5 6 7

Much Narrower — Much Broader

Section D

This section asks about computer usage and general Information Technology knowledge. (Please circle the appropriate number)

D-1. How thorough is your current knowledge of "**computer hygiene**" (e.g., How to make a computer system secure, to perform proper backups, recover from a malfunction, and other measures to ensure your computer operates efficiently)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-2. How thorough is your current knowledge of **computer hardware concepts** (e.g., How a computer works, role of the processor, the main memory, secondary storage, input and output devices)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-3. How thorough is your current knowledge of **computer hardware peripherals** (e.g., How to connect to a computer, install a driver, and operate peripherals such as printers, external drives, and scanners)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-4. How thorough is your current knowledge of **software principles** (e.g., structured programming, the advantages and disadvantages of various programming languages)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-5. How thorough is your current knowledge of **system performance** (e.g., How the various components impact the system's speed and throughput)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-6. How thorough is your current knowledge of **software installation** (e.g., How to test a computer program, download software and install it so as to insure that it functions correctly)?

(Circle Number) 0 1 2 3 4 5 6 7

No Knowledge ... Complete Knowledge

D-7. How thorough is your current knowledge of **computer policies and plans** within your organization?

(Circle Number)	0	1	2	3	4	5	6	7
	No Knowledge							Complete Knowledge

D-8. How thorough is your current knowledge of the **potential for using computer technology** within your organization/unit?

(Circle Number)	0	1	2	3	4	5	6	7
	No Knowledge							Complete Knowledge

D-9. On the average, how frequently do you use a computer system at work?

1 LESS THAN ONCE A WEEK
2 ONCE A WEEK
3 A FEW TIMES A WEEK
4 ONCE A DAY
5 SEVERAL TIMES A DAY

D-10. On those days you use a computer, what is the average time you spend on the machine?

1 LESS THAN AN HOUR
2 1 TO 2 HOURS
3 2 TO 3 HOURS
4 3 TO 4 HOURS
5 OVER 4 HOURS

D-13. How often do you use a computer to solve new and challenging problems at work?

Never Frequently
1 2 3 4 5 6 7

D-14. How capable are you at using computers to solve new and challenging problems at work?

Extremely Poor Extremely Good
1 2 3 4 5 6 7

D-15. In general, how creative would you say you are in using software packages to solve business problems?

Extremely Uncreative Extremely Creative
1 2 3 4 5 6 7

D-16. In general, to what extent are you innovative when using software packages to solve business problems?

To a Large Not at All Extent

1 2 3 4 5 6 7

D-17. How often do you try to apply a computer in new ways when solving a problem?

Never Frequently

1 2 3 4 5 6 7

Section E

This section asks about your attitudes and beliefs toward computers. (Please circle the appropriate number)

All things considered, my use of computer systems in accomplishing various job related tasks is:

	Extremely		Neither		Extremely	
E-1. Bad	1	2	3	4	5	Good
E-2. Foolish	1	2	3	4	5	Wise
E-3. Unfavourable	1	2	3	4	5	Favourable
E-4. Harmful	1	2	3	4	5	Beneficial
E-5. Negative	1	2	3	4	5	Positive

	Strongly Disagree		Neither		Strongly Agree
E-6. I am more efficient with computers than without.	1	2	3	4	5
E-7. Using a computer enables me to accomplish tasks more quickly	1	2	3	4	5
E-8. Using a computer improves my performance in my job	1	2	3	4	5
E-9. Using a computer increases my productivity	1	2	3	4	5
E-10. Using a computer enhances my effectiveness in my job	1	2	3	4	5
E-11.Using a computer makes it easier to do my job	1	2	3	4	5
E-12. Learning to operate a computer is easy for me	1	2	3	4	5

E-13. I find it easy to get a computer to do what I want it to do	1	2	3	4	5
E-14. My interaction with a computer is clear and simple	1	2	3	4	5
E-15. I find computers to be flexible to interact with	1	2	3	4	5
E-16. It is easy for me to become skillful at using a computer	1	2	3	4	5

Section F

This section asks about your satisfaction with computers in your organization/unit. (Please circle the appropriate number)

	Strongly Disagree		Neither		Strongly Agree
F-1. The computer system provides the precise information I need.	1	2	3	4	5
F-2. The computer system is user-friendly	1	2	3	4	5
F-3. The reports provided by the computer system meet my exact needs	1	2	3	4	5
F-4. The information is presented in a timely manner	1	2	3	4	5
F-5. Information the computer system presents is accurate	1	2	3	4	5
F-6. The information the computer system presents meets my needs	1	2	3	4	5
F-7. The output is presented in a useful format	1	2	3	4	5
F-8. The information is presented clearly	1	2	3	4	5
F-9. The computer system provides sufficient information	1	2	3	4	5
F-10. The computer system is easy to use	1	2	3	4	5
F-11. I am satisfied with the accuracy of the computer system	1	2	3	4	5
F-12. The system provides up-to-date information	1	2	3	4	5

Section G

The remainder of the questionnaire asks information about you.

G-1. What is your AFSC/Job Series? ____________________________

G-2. What is your Rank/Grade?

1 E-1 to E-4
2 E-5 to E-6
3 E-7 to E-9
4 O-1 to O-3
5 O-4 to O-6
6 GS-1 to GS-4
7 GS-5 to GS-9
8 GS-10 to GS-14
9 Other ____________________

G-3. How long have you worked for the Air Force? (0 = less than a year)_____Years

G-4. How long have you worked in your AFSC/Job Series? (0 = less than a year) _______Years

G-5. How long have you used computers on a regular basis? (0 = less than a year)

a. In the workplace _______Years
b. At Home _______Years

G-6. What is your age? _______Years

G-7. What is your gender?

1 FEMALE
2 MALE

G-8. What is the highest level of education you have completed (Circle number)?

1 HIGH SCHOOL
2 TECHNICAL/VOCATIONAL SCHOOL
3 ASSOCIATES DEGREE
4 BACHELORS DEGREE
5 MASTERS DEGREE
6 DOCTORAL DEGREE

G-9. From which sources have you received computer training?

\# of Classes/Subject areas

a Classes offered by AF organizations _____
b Classes offered by vendors outside the AF? _____

c Subject areas Studied thoroughly (self-taught)? ______
d Classes offered by other sources? ______

G-10.   Please add any comments you wish to make in the space bellow.

___

___

___

Thank you very much for your assistance.   (SUBMIT)

Appendix B: Survey Email Messages

From: Case David 1stLt AFIT/ENV
Sent: Wednesday, November 06, 2002 8:33
To: **MASKED**
Subject: User Effectiveness Survey

Hello,

I am a graduate student at the Air Force Institute of Technology here at WPAFB. I am conducting a study which involves the effectiveness of personnel who use computers on a regular basis. This survey was approved by ASC and AFGE leadership. If you have questions/comments, please feel free to send an email.

You were selected based on your status as an employee of ASC at WPAFB to participate in a study sponsored by the *Office of the Air Force Chief Information Officer, Aeronautical Systems Center, Human Resources, Transformation Objective Team* and *Information Technology Reskilling Team*

Your name was randomly selected from all ACS members on the Global Address List.

The survey will take 10-15 minutes to complete.

This is your opportunity to provide inputs which may aid AF and ASC leaders make decisions on funding for information technology training and investments; your inputs are highly valued, but your participation is totally VOLUNTARY.

All questions must be answered in each section before moving to the next section
If you get interrupted while taking the survey, you can return to the survey, but must start from the beginning.

For additional information and instructions, follow the link below to the on-line survey.

User Effectiveness Survey

Thank You!

David A. Case, 1Lt, USAF
Graduate Student, Air Force Institute of Technology

From: Case David 1stLt AFIT/ENV
Sent: Tuesday, November 19, 2002 8:35
To: **MASKED**
Subject: User Effectiveness Survey Reminder

Good Morning!

This email is a reminder to those who have not completed the User Effectiveness Survey—please delete if you have completed the survey.

If you have filled out the survey—thank you for your time and inputs.

If you have not filled out the survey, please follow the link below to complete the ASC/CC and AFGE approved user effectiveness survey.

You have until COB 21 Nov 2002 to complete the survey. At that time the survey will be taken off line.

This will be the last email you will receive reference this subject.

Thanks again for your time and patience

V/R

David A. Case, 1Lt, USAF
Graduate Student, Air Force Institute of Technology

From: Case David 1stLt AFIT/ENV
Sent: Wednesday, November 13, 2002 11:47
To: **MASKED**
Subject: User Effectiveness Survey Troubleshooting

Good Morning!

Several people have had difficulty accessing and completing the survey. The website technician and I troubleshot the survey all morning. The most common error, which occurs while submitting the responses to section G, is a pop-up box with the phrase "Please select answer for question a." Unfortunately, all questions in each section must be answered (contrary to the instructions) before moving to the next section. The pop-up is fixed and will tell you specifically which question was not answered.

I humbly request, if you have encountered an error, to attempt the survey again. The survey website will run until COB 21 November.

User Effectiveness Survey

Thank you all for your patience and understanding

David A. Case, 1Lt, USAF
Graduate Student, Air Force Institute of Technology

Appendix C: Participants' Comments

Many of the questions are not appropriate. In that, it was not asked if I use my computer for more than email and generating charts/briefings. The answer is no. Thus I have neither need nor desire for additional software packages especially programming languages. Many of the questions should have a second column response with "not applicable to my job".

Another point is the lack of knowledge in the software/ hardware. It reflects how unfamiliar I am in many areas. But then again, I have no need to know about those areas,,,much like I need to know the how many hairs on a caterpillars back which lives in southern Indonesia. Would I care to learn if it has no application? I answered sections E and F and portions of the rest of the questionnaire in regards to email alone since this is what I use the computer for 99.99 % of the time.

I'm 98% comfortable/confident with the use of computers. Build PCs as a hobby and enjoy/fascinated with the technology.

The server gets overloaded quite often and some of the software applications get "locked up", resulting in a work "stoppage" for everyone in the office.

Current trend of web-based applications to perform mission without increase in bandwidth/infrastructure is actually making job harder, not easier. Data integrity is beginning to suffer as updates to web applications go up and down corrupting data at storage source.

Been Involved with computers since the Commodore Vic-20. Every thing I have learned is self-taught minus the basics and basic programming.

I am a strong proponent of independent self-direction learning

The computer is a tool. I keep hitting keys until I get it to do what I need it to do. It isn't a tool for everything. Some tasks are better done without a computer (post-it notes, etc.)

Section E was confusing. My computer does not do anything. It does not give me reports.

I can see I have much to learn

In the overall scheme of things, I think computers have definitely assisted me in performing my duties more effectively and efficiently. However, my career field is required to use a system that is tied to the base Internet connection. Consequently, we

frequently run into annoying slowdowns in the system, because the Net gets bogged down. We have spoken to the owner of the process about setting up on Internet connection for this system (which is used base wide), but have been told this is not allowed. Talk about frustrating......

Most computer courses are taught by instructors who think the students are raised with computers and are intimately knowledgeable about their workings. This may be true for people below the age of 30 but not the aging workforce. When it comes to computers, you can teach an old dog tricks, but it takes more time for him/her to understand, assimilate, and create a working relationship with a machine that does not understand his/hers technical limitations and provides no rationale feedback why the action taken is not correct or will create a fatal error. Until the commercial software is really user friendly and tells the reason why a fault occurred or why an action input is invalid, the user will not be able to comfortably use the computer, or learn a program sufficiently to use it to do a job without high levels of anxiety.

I'm not sure how effective this survey is at getting to what the basic issue is - computers should be easy, self-explanatory tools to help with the job. As soon as I need to take a class to learn how to use the tool, it's usefulness is questionable. A computer should be like a pen or a phone, used without expending any mental capital. The information presented by the computer should be the academic exercise, not getting to the information or presenting the information to someone else.

Answers concerning downloading software are based on no working knowledge of how the MIS department at work would have us use software and have it interact properly to the network. If the download were done to a stand-alone system, the answers would be different.

Computers have made the job more difficult due to e-mail. People no longer talk to each other, they e-mail the world and then I spend a lot of time answering e-mail. The software and hardware we use doesn't usually have any user friendliness requirement. Your survey isn't fully appropriate to me as I work in an acquisition office and most of my computer use is for reading & generating stuff that goes on e-mail rather than a system that generates data for my use.

It would be great if they would quit "upgrading" and creating more problems for the users.

Please eventually publish results.

It amazes me the number of employees who still don't know how to use common software package, i.e. Microsft Office

Most learning takes place through OJT. New office type software is so user friendly that very little, if any, training is required to become proficient. I rarely must deal with more complex type software

I don't understand the basis of the questions on the usability of the data from computers. That information is dependent on the timeliness of the people updating it and providing it. There seems to be such an information overload for everyone that they can't keep their own web-sites updated. (or other data sources.)

I really don't use my computer for much more than communicating via e-mail and getting information from various web sites. My big issue is that I get inundated with too much e-mail--especially e-mail with attachments. Getting up to speed on new software is too daunting a task, so I generally let others do so unless I absolutely have to do so to accomplish my job.

Trend I've noted - the requirement to interface with more and more data systems takes more and more of my time, making me more unproductive - hopefully there are resulting productivity advances elsewhere is the system. A good research topic would be the impacts of turning higher-grade employees into part time data entry clerks.

Difficult to answer some of the questions since I can only assume the level of knowledge of the other people in my organization. We do not discuss regularly.

I feel very competent in the use of the computer for the tasks I require for my job.

Since the computers have been around, they are supposed to help us to more efficient and productive. However, more taskings are coming through the computers and therefore, our workload increases and not as effective as we like.

Not bad! I'm 39 miles from Iraq filling out your survey in a tent. Computers are sooooo cool aren't they!

Everyone needs to increase their ability to leverage information technology, it never stands still, so no one can stay an expert without significant investment. I encourage the web based application training be brought back so it can be used as just in time training.

I strongly believe that without computers I would be less efficient. However, there might be one exception/problem area that I deal with on a daily basis, and that is e-mail. I spend way too much time reading/evaluating the massive amounts of messages received daily.

More training to the end user is required for updates/new application software

I find that I can effectively manage most of my work through the e-mail systems, with reliance on word processing functions to prepare documents. My proficiency is not great,

but my effectiveness is high, even with limited formal knowledge and skill of the "nice-to-have" functions. I could benefit greatly by completing some formal training; however, I have not taken advantage of many opportunities due to conflicts with other activities, and/or lack of sufficient interest.

One of the huge benefits I find is the ability to communicate effectively and quickly with people from various locations; however, this same capability is a big drawback due to the proliferation of unnecessary taskings and superfluous e-mail messages.

Flooded with e-mail that is out of date or not pertinent/no interest

Specific programs (ConWrite, SPS,GUI) that the contracting people have had to use are almost worthless, change too frequently and negate any previous learning accomplished prior to upgrades. This in and of itself makes the completion of the contracting task very stressful.

Would like to see more Software application classes offered.

Since most acquisition individuals use MSWord, email, and the internet, much of the training proposed is unnecessary.

Also, I don't get paid additional money to be my own "computer help desk", even if I had the skills. That is why the government pays for computer support, either on services contracts or through use of in-house government computer specialists. I believe that part of the reason the Navy is going to the Navy Marine Corps Intranet (NMCI) is to have standardization in HW/SW and computer support. Way too many engineers are fixing/upgrading their own computers when they are being paid to do engineering work on aircraft/weapons systems during that timeframe.

Most learning from self-study. Little support for development, innovative use, and problem solving that would support improved productivity by personnel seeking to do their work more efficiently.

I'm interested in taking computer classes but I'm on the waiting list through our training monitor for the class to become available.

Quality judgments in Sections E & F don't capture some relevant system-specific issues. Examples: certain computer systems allow for increased productivity and provide time savings (positive influence). Others are relatively difficult, time consuming, and inaccurate (negative influence). Computers MAY save time distributing and collecting information), but they can limit one's ability to "sell" personal ideas. Comm studies have shown that the verbal or written piece of an overall message pales in comparison to the information communicated through non-verbals. Computers, without the aid of interactive video, are not capable of replacing face-to-face meetings although they can assist with the preparatory functions. As managers and leaders, we need to be very

concerned about the way stakeholders perceive, interpret, and then act on information we provide. Finally, the ease with which computer networks can distribute information has led to poor discipline and widespread information overload

I gained a lot of computer knowledge during college both in class and on my own. I found the questions on this survey to be difficult because they were so vague.

ASC is great at offering software computer courses. However, the problem is finding the time to take the courses. With personnel cut-backs there isn't enough time to do your job... much less take courses. You pretty much have to teach yourself (which basically means you are going to miss out on some useful information that could have made your work more efficient - it just didn't know how to make the software perform that task).

G-8. "education" spelled wrong. Section F seems to assume interaction with a mainframe, which I do not. Good luck on your project.

I used to program mini computers in assembly language. I know how computers operate. It does me no good in what I do in using them today. The power of the software packages I use most (Word, e-mail, Powerpoint, etc) is far greater than I have time to learn. I don't have time to learn things. It's frustrating when software doesn't do what you want (for instance no hanging indents in Word) and you have to waste time trying to use worthless Help directories in the software. Most of us don't need the power given us and it has slowed us down. Yet, computers are now so much a part of our office life, we can't do without them.

I need help doing some of the interworkings of computers to add software to my computer, etc. I can type at 100 wpm but not very good at programming, etc

In my opinion, the management level that I entered the Officer Corps at has not allowed me to become technically proficient in any one software product. I have been exposed to many systems, but not at the level of depth I would have liked. My current position in Acquisition requires depth in many of the systems that I have only management experience. The learning curve is steep and frustrating at this time in terms of computers and computer software. The remedy is time, exposure and responsibility--it's been the only way to learn.

Systems lag software. SPO just replaced 300 MHz running Win2000, very slow. Need more flexibility in users defining software needs. Often, users find more efficient and easier to use software, that is not part of the standard load, and cannot convince computer group to purchase.

Finance should give more computer training.

Section A - There should be a question regarding chart making/slide presentation software applications (PowerPoint, Harvard Graphics, Corel Draw, etc.)

Section F - There should have been a question regarding the "timeliness" of data.

The computer classes offered on base are usually geared to the slow learners and not to those of us who can and will learn quickly.

The only formal computer classes I took were Basic and FORTRAN programming in college (undergrad). The remainder of my computer training is self-taught.

There are some issues with the infrastructure support causing down time/delay in using the computer. It is an essential tool but cannot substitute for Education/Experience.

Largest productivity enhancement is ability to communicate with other on and off base

Our organization's primary mission is analysis using modeling & simulation. Currently PCs play a small role, but we are beginning to transition to linux platforms from workstations.

For myself, the task of managing my Outlook mailbox interferes with getting my job done.

e-mail is good and bad. can spend entire day responding to e-mail without getting primary tasks done. Information is often hastily put together and sometimes inaccurate.

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Vita

Lieutenant David A. Case was born in Plattsburgh, New York. He graduated from Mount Assumption Institute High School in 1986 and soon after, enlisted in the U.S. Army. He served as a Radio Teletype Operator and rose to the rank of Specialist before being honorably discharged from active duty in 1990. He continued his military career in the New York State National Guard as an Infantryman from 1990 until 1996. After receiving an Associates degree in Criminal Justice Sciences from Clinton Community College in 1994, he enrolled at New Mexico State University and entered the AFROTC Commissioning Program in 1996. He graduated with a Bachelor Degree in Business Computer Systems on 15 May 1999 and received his commission the same day.

Lieutenant Case's first assignment was to Lajes Air Base, Azores, Portugal where he led the Telephone Operations and Plans & Programs sections. He finished his tour at Lajes as the Support Group Executive Officer. In August 2001, he entered the Information Resource Management Master's Degree Program, Graduate School of Engineering and Management, Air Force Institute of Technology, Wright Patterson AFB, Ohio. Upon graduation, he will be assigned to the Air Force Technical Applications Center, Patrick AFB, Florida.

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14. ABSTRACT

The tremendous proliferation of end user computing (EUC) in the workplace over the past few decades is cause for concern in public and private organizations. Computer use has moved from individuals working with "dumb" terminals in centralized networks to individuals operating personal computers, just as powerful as yesterday's mainframe. The end user has had to evolve and will continue evolving as well; from someone with low level technical skills to someone with a high level of technical knowledge and information managerial skills. Because EUC continues growing more sophisticated, end users must not only maintain a level of competence, but prepare for the next generation of computing technology. Doing so will enable organizations to continue enjoying the positive benefits of EUC success. Research indicates that EUC success may depend on end user competence. Using Structural Equation Modeling (SEM) to test an integrated model of EUC success, the results of this study show that computer training, education level, beliefs about computer systems and the ability to operate them lead to end user computing competence. Additionally, results show that computer system use, a factor in achieving EUC success, is an outcome of end user computing competence. The overall conclusions drawn from this study is that the Air Force organization may be able to improve its efforts to successfully use computing technology, however it appears individual personnel have the competence to do so already. There may be additional underlying factors contributing to the lack of significant computing success, the discovery of which is a prospect for future research.

15. SUBJECT TERMS

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